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Invited ViewPoint

COVID-19 Risk Assessment Tool: Dual application of risk communication and risk governance

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ABSTRACT

Risk awareness is the best way to prevent and slow-down the transmission of the COVID-19 pandemic. Risk awareness is achieved through communication of risk assessment. Effective risk communication is an important measure to control the infodemic. Most risk assessment tools focus on either tracking the affected patients or diagnosing a probable health condition through symptoms. RIKA India introduces an innovative Risk Assessment Tool which goes beyond the symptom detection and patient tracking. It includes four factors in assessment of risk: Health, Behaviour, Exposure and Social Policy. Each of these four factors have sub-factors which help to assess the overall risk in a more comprehensive way and also present it to the user in a simplified way. The paper discusses the importance of the Risk Assessment Tool for awareness generation and decision making. Further, the datasets generated through the tool have been analysed to understand the key intervention areas for COVID-19 response and management.

1. Introduction

The coronavirus pandemic has yet again shown that we as a global society are not fully resilient to a health emergency of such a scale. The world has previously seen global health emergencies of Ebola virus in 2014, H1N1 (Swine Flu) in 2009 and SARS in 2003. Having faced such serious outbreaks, there are many lessons for the affected countries and the rest of the world to adapt to, and come out of this as a resilient society. The Novel Coronavirus (2019-nCoV) later named as COVID-19 disease, began as an outbreak in Wuhan province of China, before making its way around-the world in a matter of months and becoming a pandemic. As per Shaw et al. [1] this pandemic is characterised by: i) rapid spread, ii) aged and low immune people are more vulnerable and iii) differential recovery rate. As currently there is no vaccine for COVID-19, neither is there any confirmed treatment, therefore, the best way to prevent and slow down the transmission is to be well informed about its causes and how it spreads. WHO declared COVID-19 as a Public Health Emergency of International Concern (PHEIC) on the 30th of January 2020. This declaration means that the disease outbreak concerns more than one country and thus requires a coordinated international response [2]. While writing this paper the latest data of number of affected people of COVID-19 stands more than 4 million people with number of mortalities at 300,000 [3].

COVID-19 pandemic, as a public health emergency, has brought into light many challenges in our lives and livelihoods. It has brought into picture the need for a trans-disciplinary view of the current crises through various angles of global governance, technology and risk communication [4]. COVID-19 has posed not only health but economic and geo-political crises too. It is thereby a humanitarian challenge [5]. While health organisations and governments advise many preventive measures like social distancing and personal hygiene, one of the foremost strategies remains risk communication and awareness generation to break the chain of spread. Awareness and understanding of the risk at the community level goes a long way in enhancing prevention. In this regard, various risk assessment tools in the form of mobile applications or online surveys are being actively used. Such tools are intended to analyze the probable risk of the respondents based on information provided on current health status. Most of the tools majorly focus on the health diagnostics aspect of the risk wherein the observed symptoms are assessed to assign a category of risk with some platforms providing GIS based analysis of the geospatial risk based on current location of the confirmed cases. This leaves the understanding of risk limited to medical conditions. However, Cheng and Kwang [6] points out at the role of many inter-connecting factors such as social behaviour and exposure which contribute to the risk of contracting the disease as observed in the case of SARS. In case of COVID19 also, observing personal hygiene like

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avoiding to touch face, wearing masks, frequent washing of hands as well as social/physical distancing is prescribed. All these factors essentially are part of community and social behaviour and become part of the governance. As per Shaw et al. [1] citizen compliance and behaviour resulted in containment of the spread in China and other countries.

Amidst the management and response to the COVID-19 pandemic, this paper has two specific objectives. One is to explores the use of innovation and technology in assessing the people's behaviour in pandemic response. Two to see how four parameters (health, exposure, Behaviour and Social Policy) are linked. The paper introduces Covid19 Risk Assessment Tool developed by RIKA India (Indian based social entrepreneurship start up, which works on disaster risk reduction, environmental management and sustainable development) as an innovative strategy for risk assessment, communication, decision-making and awareness. The first part explores the risk assessment and risk communication in the context of emergencies and specifically for COVID-19 pandemic. It undertakes a review of existing risk assessment and information tools available online in the form of apps and surveys. The second part concentrates on key features of RIKA's COVID19 Risk Assessment Tool and discusses the methodology used for development of the tool. The third part focusses on data analysis based on the responses of the Risk Assessment Tool. The data analysis uses Pearson's correlation coefficient to understand if there exists any linear relation between two variables and also to identify the strength of such relationship, if it exists. The analysis is followed by key inferences and conclusion.

2. Overview of existing COVID-19 related tools

Risk assessment is an important step in disaster risk reduction where it enhances the understanding of risk and allows information to decide on adequate preventive and mitigation measures. Core methodologies for disaster risk assessment include hazard, exposure and vulnerability assessment. Risk assessment is also widely used in the context of health, safety and environment. It involves evaluation of existing conditions of vulnerability, the impending hazard, existing exposure and current capacities for prevention. Risk models specify the factors which are needed to assess risk and the relationship among those factors, producing a sort of template for risk assessors to use in their assessments. Health risk assessment tools have been developed to assess individual risk for particular diseases.

Shaw et al. [1] points out the need to have a proper risk assessment including factors of health risk, governance, exposure and citizen behaviour. To strengthen the community level response, a coordinated approach of disaster risk governance from Sendai Framework point of view is needed to manage this public health emergency. In the case of China, emerging technologies like Artificial Intelligence (AI), Big Data, 5G technologies, drones, automated vehicles, robotics etc. were used to track, monitor and support logistics in management of Covid19 [ibid]. Technological risk assessment models can quickly analyze irregular symptoms and other similar red flags and thus alarm the community and the healthcare authorities. This helps to improve the planning, and awareness activities for patients on an evidence-based model. Further it helps to provide faster decision making, which is cost-effective. Such tools can help analyze the extent of infection spread by this virus by identifying the clusters and hot spots and can successfully do the contact tracing and monitor of the individuals [7].

COVID-19 is as much a pandemic as it is an infodemic [5]. WHO Information Network for Epidemics (EPI-WIN) [8] was launched as a new information platform to share customized information with specific target groups. The data on COVID-19 is dynamic and changing at a fast pace. COVID-19 hotspots (areas with affected cases of COVID19) are changing dynamically. This makes a control of information difficult. Social media in this regard tends to be flooded with messages many of which are not verified. As per Hua and Shaw [5], the media use for information access for the COVID-19 increased tremendously. However, the right information is the key to success in mitigation measures. The Chinese and Singapore government in this regard have checked the fake news and kept control on rumour spreading.

Risk assessment generally remains in the domain of science and technology, academia and policy makers. Providing public access to the risk assessment is done through risk communication. Community based activism such as aggressively finding suspected cases and supporting vulnerable groups was a successful advantage of South Korea to overcome the crises [36]. Japan's 26 national resilience working groups includes a high-level “STOP Pandemics 2020 Strategy Committee” which made many recommendations including on risk-communication so as to have a better integration of pandemic risks into all-hazard national resilience [9].

Risk Communication is the effective and accurate exchange of information about health risks and hazards often during an emergency [10]. The aim of risk communication is to advance risk awareness and understanding and to promote health-protective behaviour among individuals, communities, and institutions. The ultimate purpose of risk communication is to enable people at risk to take informed decisions to protect themselves and their loved ones. Risk communication is an essential part of the risk mitigation measures since it drives the public understanding, trust, acceptance and compliance with the measures. Risk mitigation is an interdisciplinary decision-making process based on information from risk and exposure assessment [11]. Risk Communication involves stakeholders like risk assessors, managers, news media, volunteer groups and the community. Risk communication uses many communications techniques ranging from media and social media communications, mass communications and community engagement. It requires a sound understanding of people's perceptions, concerns and beliefs as well as their knowledge and practices. As per Barry [12], if people had accurate information about the risks faced and the knowledge of prevention, they often performed heroically and increase the compliance to public safety advisory of the government. Risk communication, specifically, mass communication of public health information, can however have limitations of cultural issues as well as linguistic barriers, especially for the migrant communities.

In March 2020, WHO setup a ‘WhatsApp’ group for providing information and risk mitigation instructions [11]. Various countries also launched national communication measures structured in news and information websites/platforms jointly combatting fake news, aiming to encourage awareness, understanding and compliance towards restrictions. As part of such risk communication strategies, the mobile apps have come up as a means for risk communication. A summary of some of the available risk assessment tools and apps in the market is given in the Table 1.

The above-mentioned risk assessment tools are mostly based on the premise of either tracking the affected patients or diagnosing a probable condition through symptoms. These tools and apps help the government as well as the community in knowing if they have been in contact with an affected person. Amidst the concerns for privacy, many private apps have come up to aid in individual assessment of risk and contact tracing.

The RIKA's COVID-19 Risk Assessment Tool goes beyond the symptom detection and patient tracking. It intends to provide information on social behaviour and also assesses the people's compliance for the government advisory. The risk assessment score also includes the exposure of people through the type of residence, the behaviour of hand-washing and wearing mask as well as the current implementation status of restricted movement guidelines of the government.

In comparison to the Arogya Setu App by Government of India, the COVID-19 Risk assessment tool, provides awareness information in the form of questions which are also used to assess the risk based on behaviour and social compliance. Further, the COVID-19 Risk Assessment Tool generates information on anxiety levels to understand the need for psycho-social care as part of overall response. The inclusion of smoking as a risk behaviour is also not considered in Arogya Setu app or any other Risk Assessment Tool available in Asia or in the other continents. Another unique feature is the assessment of exposure based on residential type which is again missed in other available applications and tools.

3. Key features of COVID-19 risk assessment tool

The COVID-19 Risk Assessment Tool is a simple online tool which can be used to assess the risk based on multiple linked factors. The main features of the tool are that it is simple and free to use. The simplicity of the

Table 1
Summary of online risk assessment tools.

S. no.	Name of the tool	Main features
1.	Infermedica [13]	Identifies coronavirus symptoms and provides further information regarding COVID-19 concerns.
2.	Health Engine [14]	It asks questions on following parameters and provides analysis of risk: • Travel History • Corona Positive patient contact history • Symptoms of Fever etc.
3.	Henryford [15]	It asks questions on symptoms, with travel history and contact to provide risk analysis
4.	Docsapp	It is an online doctor consultation app to provide information on symptoms and whether to consult a doctor.
5.	WHO Mass Gathering Religious Addendum Risk Assessment Tool in the context of COVID-19	• It is an offline Risk Assessment Tool for organisers and planners • It Includes Mitigation Checklist for planning mass gatherings and events.
6.	Humandx.org [16]	It asks questions on age, travel history, symptoms, being in healthcare profession and co-morbidities. The assessment summary provides information on preventive steps, the need to visit doctor, get tested etc.
7.	Arogya Setu [17]	The app verifies symptoms and notifies the users if they are in vicinity of a diagnosed positive patient. Tracking is done via Bluetooth and a location-generated graph that charts proximity with anyone infected. The app also provides self-quarantine instructions.
8.	TraceTogether [17]	It is a contact tracing app that uses Bluetooth to track infected people and notify those who were in close proximity to them during the past 15 days.
9.	CovidWatch [17]	It uses Bluetooth signals to detect users when they are in proximity to each other and alerts them anonymously if they were in contact with someone who has tested positive. One unique feature of the app is that any third party, including the government does not have access to the data of who was exposed by whom.
10.	HaMagen [17]	This is launched by the Health Ministry of Israel. It uses contact tracing to contain the spread of the deadly contagion. The app allows users to know if in the past 15 days they were close to anyone who has been diagnosed with the virus.
11.	The Corona DataSpende [17]	It is a German smartwatch app which monitors the spread of coronavirus by collecting symptoms like pulse rate, body temperature, sleep patterns to detect any early signs of warning. It is done through wearing a smartwatch or a fitness tracker.
12.	PeduliLindungi [17]	It is developed by the Indonesian government. It enables users to compile data related to the spread of COVID-19 in the community and helps confirmed and suspected cases. It cross-references data stored on mobile device through Bluetooth. It enables an anonymous exchange of identities when in vicinity of another positive patient.
13.	COVID Safe	The Australian app helps state and territory health officials to quickly contact people who may have been exposed to COVID-19. The COVID Safe app speeds up the current manual process of finding people who have been in close contact with someone with COVID-19.

app lies in the fact that there is minimal data entry. The tool prominently includes questions related to awareness behaviour of the user in order to inculcate awareness. Key questions on whether social distancing is being maintained reiterate the importance of such measures. The tool ensures the implementation of risk communication to the end users. Further, the tool presents the analysis of risk in a visual format which is more appealing to the people. The tool assesses the prevalence of co-morbidities in the users which might increase their risk. As per Yang et al. [18], underlying diseases (Comorbidities), including hypertension, respiratory system disease and cardiovascular disease could be the risk factors for severe patients compared with non-severe patients of COVID-19.

Shaw et al. [1] notes that pandemic is global but its response is local. It is also pointed out that a major part of the response depends upon the culture and citizen behaviour [19]. [ibid], also notes that in Japan, people with colds, flu, or allergic, wear surgical masks as a cultural norm to prevent others from getting sick. The Japanese do not have emotional resistance to wearing masks, whereas people in other countries need to be informed on the need of wearing mask to prevent themselves as well as others. The survey assessment tool assesses the people's behaviour in wearing masks and can help overcome emotional resistance to adhering to government guidelines on restricted movements and sanitation practices. The study of Cheng and Kwang [6] demonstrated that although knowledge is important for performing SARS-preventive behaviours, social norm is also an important factor.

The assessment tool allows the users to take adequate measures with respect to the risk outcomes of high, moderate and low. The assessment tool also allows the measurement of risk perception through the level of anxiety shown by the user in the current scenario. The Risk Assessment Tool fights the infodemic. It shares the personalized risk assessment information. The data analysis can also provide insights into how many people are taking hand-washing seriously. It can detect the need for mental health risk assessment through anxiety level. The tool is a low-cost technology-based solution to provide assessment of individual risk as well as increase community awareness. The tool is customizable in various languages and is currently available in seven languages. The tool also adheres to the privacy norm by not collecting any personal information of the user like phone number or email ID.

3.1. Methodology for tool development

The COVID-19 Risk Assessment Tool is broadly based on four major factors of health, exposure, behaviour and social policy. Each of these factors have sub-factors which are based on findings from studies conducted in China and Italy [27]. The various parameters used to develop the assessment tool can be categorised as shown in Table 2 below.

Each of the parameters are assigned linear weights based on the responses in the given options (Annex-1 for details). The given weights for each parameter except for health are summed up and then average is calculated. The calculation is listed in Table 3 below.

The basic premise for calculation is that age and health is the inherent individual vulnerability that is being exacerbated due to individual exposures and individual behavioural elements. Gender has also been found to be a prevalent determiner of risk to COVID-19. The behaviour factor be5 and be6 are not scored for calculation of risk. Based on the above weightage the risk is calculated as:

$$\text{Risk} = (\text{HR} * 0.5) + (\text{Be} * 0.2) + (\text{Ex} * 0.2) + (\text{SP} * 0.1)$$

The output based on the above calculation gives us three different scenarios of risk as depicted at the end of the assessment: low, moderate and high risk along-with a general information advisory (Fig. 1 below).

This application has been deployed on Amazon Web Services (AWS). AWS Simple Storage Solution (S3) is used to host the user interface (web site). The user interface has been developed using AngularJS and Responsive Web Design. To distribute the web site content AWS CloudFront (Content Distribution Network, CDN) is used so that customers across the world can access it with low latency and high transfer speed. Survey Data is submitted from https://www.covid19risk.net web site to AWS API Gateway,

Table 2
Factors of risk assessment.

Health (HR)	Behaviour (Be)	Exposure (Ex)	Social policy (SP)
Age(A)	Use of Mask (Be1)	Residential Type (Ex1)	Effectiveness of Lockdown (SP1)
Co-Morbidities (Cm)	Hand-washing (Be2)	Occupation (Ex2)	Community Compliance of social distancing and mask use (SP2)
Gender(G)	Sanitizing before touching face (Be3)	Travel History and Mass Gatherings (Ex3)	
Smoking Habit (Sm)	Practicing Social-distancing norm (Be4)		
	Anxiety based on current situation (Be5)		
	Trust in government's measures (Be6)		

Table 3
Calculation for risk assessment factors.

Factor	Calculation	Weightage
Health Risk (HR)	Summation of A, Cm, G and Sm	50%
Behaviour (Be)	Summation of four Be(s) and then divide by 4[a]	20%
Exposure (Ex)	Summation of all Ex(s) and then divide by 3	10%
Social Policy (SP)	Summation of all SP(s) and then divide by 2	10%

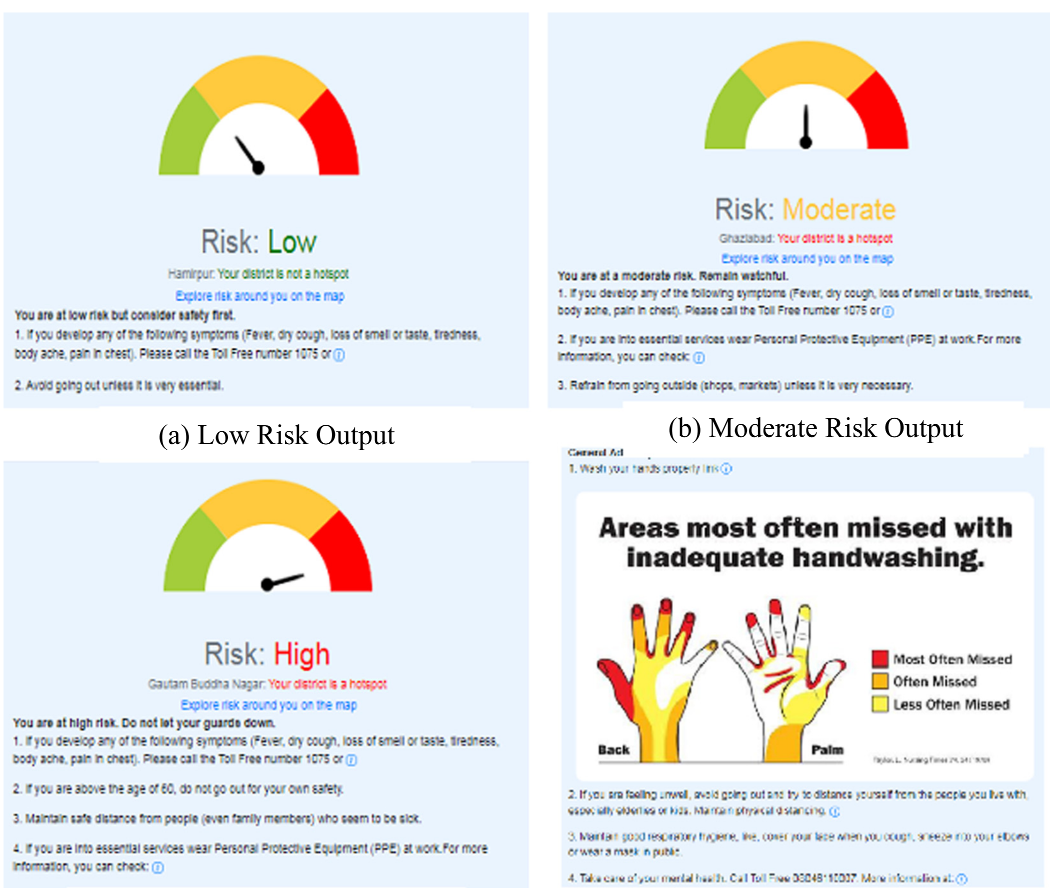
[a] For behaviour factor, Be1, Be2, Be3 and Be4 are only considered to calculate risk. Be5 and Be6 are not calculated owing to their dynamic and qualitative nature.

which internally calls AWS Lambda function to store the survey data into Amazon DynamoDB Database. Entire application is serverless and it scales out and scales in automatically based on the usage. The cost associated with this kind of architecture is very minimal. Further, the geotagged locations for each respondent are plotted on a map to show the respondents the probable risk around that location and also the pre-identified hotspots by the government.

3.2. Methodology for data analysis

The COVID-19 Risk Assessment Tool was launched in India on 11th April 2020. Between 11th April and 4th May 2020, a total of 2216 responses were recorded. Of these, the data of test users and users with identified repetition was excluded to have unique response. This was done by application of filters in the data set using SPSS software. Two filters: IP address and Names were used to exclude the duplicate entries. As a result, a total of 1293 respondents' data is used to analyze the emerging trends and patterns.

The Statistical analysis used SPSS software (IBM Statistics 20) to sort the data and understand relationship between variables using percentages, graphs and Pearson Correlation. The Pearson correlation analysis was used so as to understand the linearity between variables. As observed in [22], the Pearson Correlation can provide understanding on the relationship between variables. The assessment measured the variables of behaviour across different age groups, between variables of behaviour with each other, between social policy and behaviour, between behaviour and exposure, between co-morbidities and age and other different



(a) Low Risk Output
(b) Moderate Risk Output
(c) High Risk Output
(d) General Advisory

Fig. 1. (a) Low risk output, (b) moderate risk output, (c) high risk output, and (d) general advisory.

combinations to understand and quantify the relationship of variables. Pearson's correlation coefficient was calculated to compare quantitatively the similarity between tow variables and to indicate quantitative discrepancies in the similarity. Pearson's correlation coefficient (ranging from −1 to +1) is a measure of the strength of the association between the two variables. A value of +1 is the result of a perfect positive relationship between these variables. Annexure-2 presents a summary of the results obtained from applying the correlation coefficient for different variables. The correlation coefficient is studied as per [24]. If the coefficient value lies between ±0.50 and ± 1, then it is said to be a strong correlation. If the value lies between ±0.30 and ±0.49, then it is said to be a moderate correlation. When the value lies below ±0.29, then it is said to be a weak correlation. There is no correlation when the value is zero.

3.3. Data collection strategy

A spoke and wheel propagation strategy were adopted for disseminating the tool. The tool was shared with various groups through WhatsApp, Facebook and through personal networks over email. Further, it was requested for the users to share it further within their own networks. The featuring of the tool on International Science Council and GDFRR Newsletter gave it wider audience and credibility.

3.4. Limitations

The limitations of the study pertain to limited sample size of analysis with 1293 samples. Further, the data from the survey tool may not be equally represented from each state, thus giving partial spatial analysis. The study uses the weighted variable to understand trends and patterns in place of absolute numbers. This is because the tool is meant to categorise risk based on the information and not for the survey as a primary objective.

4. COVID-19 risk assessment tool in India and key findings

The COVID-19 Risk Assessment Tool has been promoted and widely used in India. India, the second most populous country, currently has 90,000 active cases of the COVID-19 as on May 15, 2020 [20]. The string of measures taken by the Indian government have so far proved successful in containing the spread of the disease. A timeline series analysis of the measures and increase in cases is as given in Fig. 2 below. As observed, despite the strict measures, the cases of affected patients are still on a rise.

A total of 2216 respondents used the tool across various States in India between its launch and 4th of May 2020. A majority of the respondents fall in the age group of 10–39 followed by 40–49. This is possibly due to the access to mobile phone usage being especially high among the youth and young professionals (Table 4).

It is observed that 93% entries filled for the COVID-19 Risk Assessment Tool have been done by using mobile phone device. This is mainly attributed to ease of use of mobile phone and circulation of the Risk Assessment Tool through social media messages. As per Telecom statistics report of TRAI (Telecom Regulatory Authority of India), India's active mobile users reached 1026.37 million in 2018 [25,26].

Further, it suggests that the tool can thus be possibly enhanced as a mobile based application owing to the vast use of mobile phone devices. The mobile based application and a greater number of users would aid to crowd-sourcing of vital details to map the high-risk areas. The number of entries from foreign countries is 12.5%. This implies that the Tool has wide application where one can use it not only in India but also by Non-Resident Indians (NRIs) keen to check on the status of their friends and families in India. In addition, the tool can be used to take multiple surveys for family members who stay distantly. This is applicable to aged population who are not technology savvy and would need assistance of their children or other family members to fill up the survey.

As per ECDC [27], there is an increased mortality rate among males in comparison to females as have been observed among the COVID-19 patients. From the analysis of the data, only 12 people among the respondents featured in high risk and 11 of them are male, and one being the other gender. The findings are consistent with immune system variance among male, female and other gender [35]. The other gender has high risk due to compromised immune system. Further, 585 respondents fall within the medium risk category. Within this category also, the total constitution of men and other gender stands at 91%. The third category i.e. low risk has 696 of the respondents. Within this category the percentage of men stands at 68%. Thus, it re-establishes that females are comparatively at lower risk as they do not feature in high-risk category and in moderate risk also their percentage is only 9%.

Within the high-risk category, all the respondents are found to be above the age of 60 years. As per [ibid], the risk increases with an increase in age as observed in cases from China and South Korea. For Germany, Italy and Spain, the crude-case fatality increases particularly after the age of 60 years. However, there is an exception, where there are three cases in the age-group of 0–9 who fall under the medium risk. This is largely due to their residential type of an informal settlement and low compliance on behaviour factor of wearing mask, handwashing and sanitizing hands before touching face. Further, there are three cases of individuals aged 80 years and above falling in medium risk. This is attributed to higher compliance of behavioural factors and low co-morbidity score.

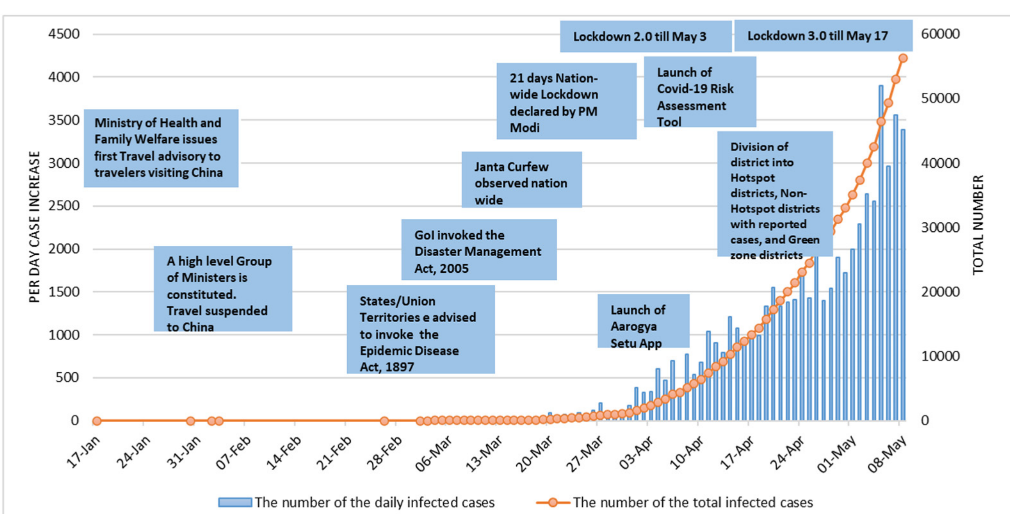


Fig. 2. Timeline Series Analysis of measures taken in India and an increase in affected cases [21].

Table 4
Descriptive statistics of respondents.

Total number of respondent data considered	
Total number of respondent data	2216
Number of duplicate and test entries	923
Total number of data considered for analysis	1293
Gender disaggregated data	
Number of males	1012
Number of females	272
Others	9
Age-group categorisation	
0–9	5
10–39	853
40–49	202
50–59	126
60–69	62
70–79	38
80 & above	7
Smoking habit	
Number of smokers	205
Co-morbidities	
Cardio-vascular diseases (heart problem)	64
Renal diseases (issues with kidney)	34
Diabetes	125
Respiratory disease chronic obstructive pulmonary disease (emphysema, bronchitis)/asthma, lung cancer	73
Tuberculosis	34
Cancer (in last 5 years) (except lung cancer)	24
Hypertension	164
Risk categorisation	
High risk	12
Moderate risk	585
Low risk	696

Spatially, maximum data entries have been received from the states of Uttar Pradesh, followed by Maharashtra, West Bengal and Gujarat (Fig. 3). While writing this paper, the state of Maharashtra has the highest number of COVID-19 affected cases with its capital Mumbai being the worst hit. Spatial analysis allows to identify areas which have maximum cases of the Covid-19 diseases and also allow the maps which are generated from crowd-sourced data to be more representative in nature.

The findings on the individual behaviour suggest that 89% people use mask and 87% people use sanitiser every time after coming home (Fig. 4a and b). However, when it comes to sanitizing hands before touching eyes, nose and mouth, 63% people are practicing it (Fig. 4c). It is often seen that we inadvertently tend to touch our face while being engaged in other tasks. As per the data reports, social distancing at individual level is being well-followed with 88% complying to it (Fig. 4d). Considering that there is no confirmed cure for the COVID-19 diseases, risk preventive behaviour is the key to mitigate and contain the spread of the disease.

Regarding the question on response to the COVID-19 outbreak, 51% people responded with the need to have new measures to bring it under control (Fig. 5) and 32% people believed that current measures are sufficient to bring it under control. This leaves scope for citizens to provide feedback with suggestions to improve the current measures of response.

With respect to anxiety, as depicted in Fig. 6, within the high risk category, there are 66.66% people who have reported being anxious due to presence of positive cases in their locality (i.e. scoring for Be5 in level 1), within the medium risk category, 36.92% people have reported similar levels of anxiety and within the low risk category, 25.67% have reported to be anxious. This states that there is more anxiety within high risk category people followed by medium and low risk categories.

In terms of effectiveness of lockdown, 75% of people have reported it to be followed with maximum compliance (Fig. 7a). In terms of mask wearing and maintenance of social distancing, 47% reported more than 80% people are following it while % people responded that some people (50–80%) are following it (Fig. 7b). Hence, while effectiveness of lockdown is being ensured, the community level compliance of wearing mask and maintenance of social distance needs to be improved.

With respect to respondent data regarding the type of residence, 40% reported it from detached houses, 30% from high rise complexes, 21% from Mohalla/chawl/shared accommodations and 8% from informal settlements (Fig. 8). As suggested in [28] building types have direct impact on the risk of spread of pandemic. The informal settlements and shared accommodations are at most risk. The high-rise apartments also increase the aggregation of people in less space.

The Exposure component is also measured in terms of occupation type (Fig. 9a). It is observed that maximum respondents (48%) did not fall in high risk occupation types (Medical and emergency professionals). Closely followed are the essential service providers (41%) who are at risk of exposure. Another important variable of exposure is the travel history including use of public transport or chauffeur driven cab and attendance of public meeting, mass congregation or wedding/conference. The 90% of the respondents have not been involved in any of these activities in the last 14 days (Fig. 9b).

Table 5 below depicts the important correlation aspects as observed from the Pearson's Correlation Analysis (Annex-2). The factors of age and co-morbidities has shown a positive and moderate correlation with coefficient of 0.434. As per Divo et al. [29] ageing population tends to be more affected by multiple morbidities. The same result is depicted by a negative

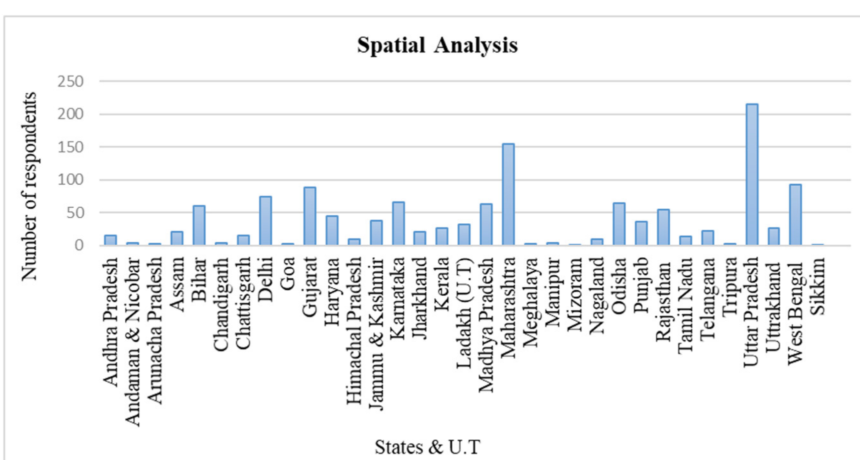


Fig. 3. State wise spatial distribution of respondents (` = 1293).

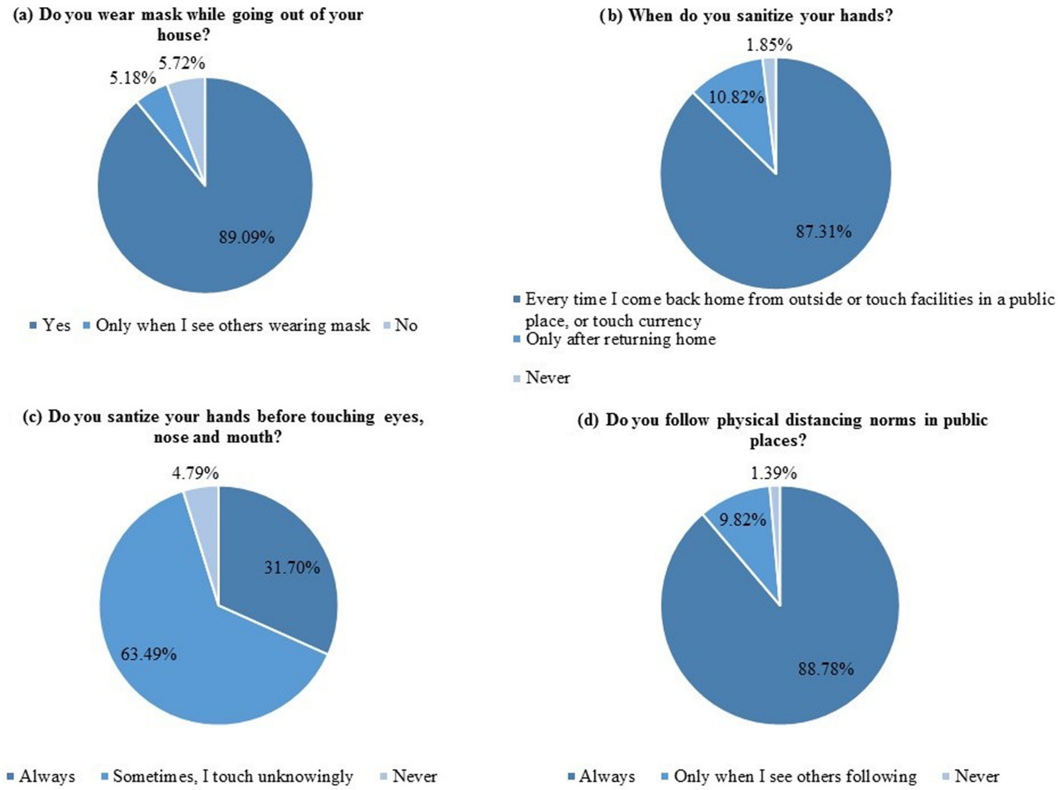


Fig. 4. (a): Use of mask; (b): use of hand-sanitiser; (c): sanitizing before touching face; (d): Social distancing ($n = 1293$).

correlation coefficient of −0.420 age-group with no disease factor. This relationship between age-group and co-morbidities is an important risk factor for Covid-19 disease too as it places the elderly population with existing disease at a higher risk of mortality. As observed, the age-group and total risk depict a strong positive correlation with coefficient of 0.835. Similarly, co-morbidities and total risk also have strong correlation with a coefficient of 0.678. Within the co-morbidities, hypertension stands-out most with a moderate positive correlation of coefficient 0.418. Diabetes also has a moderate positive correlation with a coefficient of 0.400. This means hypertension and diabetes are two important factors which increase the overall health risk. The tool gives maximum weightage to health factor in assessing the risk and this is also shown with a strong positive correlation coefficient of 0.98 between health and total risk.

With respect to individual behaviour, wearing of mask and following of social distancing norm has a weak correlation with a coefficient of 0.298. This depicts that while one may practice social distancing but might not comply with mask wearing or vice versa. However, washing hands and compliance of social-distancing has a slightly higher correlation coefficient of 0.364. The gender and behaviour show negligible correlation with a coefficient of 0.017 which means behaviour factors are not dependent on gender. Similarly, age-group and behaviour have negligible correlation with a coefficient of 0.048.

The study [27] states the need to reduce smoking as a possible preventable determinant of the Covid-19. Hence, the tool places smoking habit at a higher risk and as observed from correlation coefficient of 0.302, there is a moderate positive correlation between smoking and total risk.

There are two components considered in social policy factor: effective lockdown and community compliance of wearing of mask and practicing social distancing. Ideally, the two factors should have a strong positive correlation. However, as observed, there is a positive moderate correlation with a coefficient of 0.363 between the two factors. Further, the social

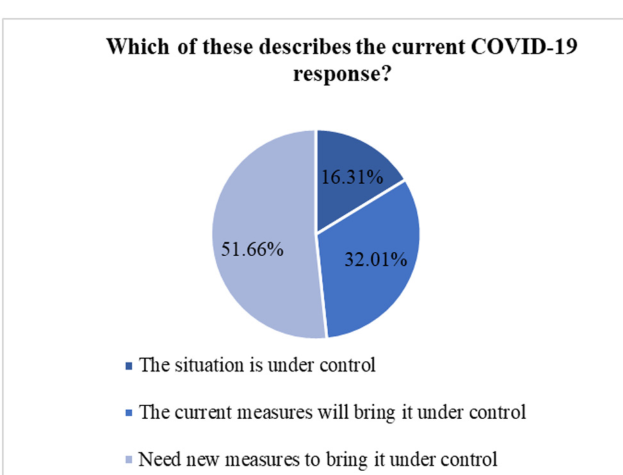


Fig. 5. Description of current measures ($n = 1293$).

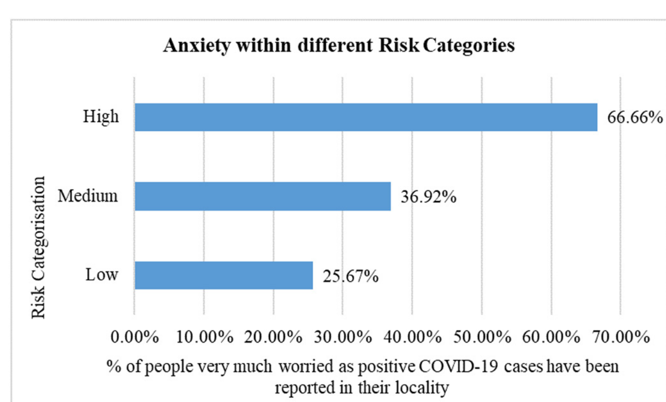


Fig. 6. Anxiety within different Risk Categories ($n = 1293$).

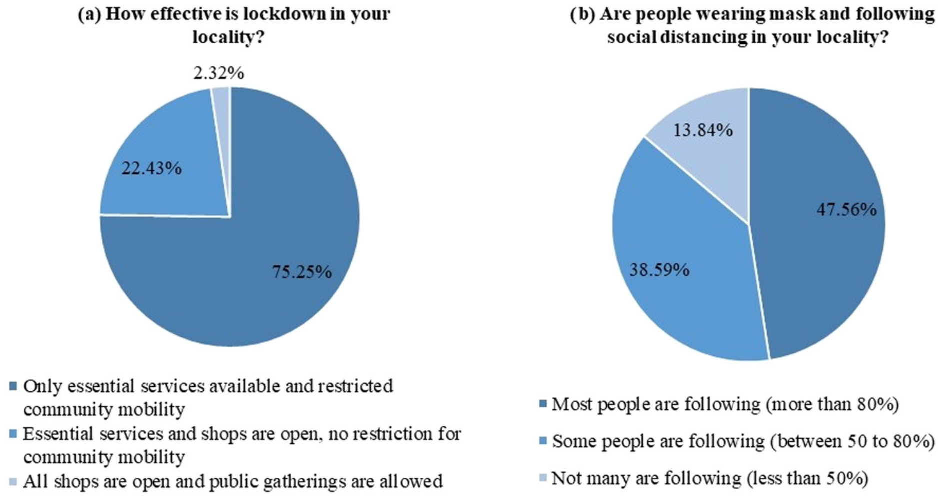


Fig. 7. Social policy compliance: (a) effectiveness of lockdown, 7(b) wearing mask and social distancing in locality (n = 1293).

policy and individual behaviour also depict a positive and moderate correlation with a coefficient of 0.266.

5. Discussion

Effective risk communication measures can result in increasing the awareness and creating social trust in the authorities [30]. Providing the right information can result in risk preventive behaviour and enhance risk governance mechanisms [ibid]. The COVID-19 Risk Assessment tool is aimed at awareness generation, risk communication and aiding in decision-making. As per Lin et al. [23], increase in information gathering with respect to google searches on hand-washing and wearing masks correlated with lowering the speed of COVID-19. The role of technology has emerged as of great importance in emergency management specially for risk communication. The important issue is how the technology can be used with proper governance mechanisms so as to enhance the capacity of the decision-makers in government set-up. The study has shown that the risk assessment tool is majorly being used via mobile devices and can thus be possibly enhanced as a mobile based app. Further, as per Silver et al. [31] the younger population are more likely to own a phone than the adults. This also features in the higher number of entries received from the age-group pf 10–39 than the other age-groups.

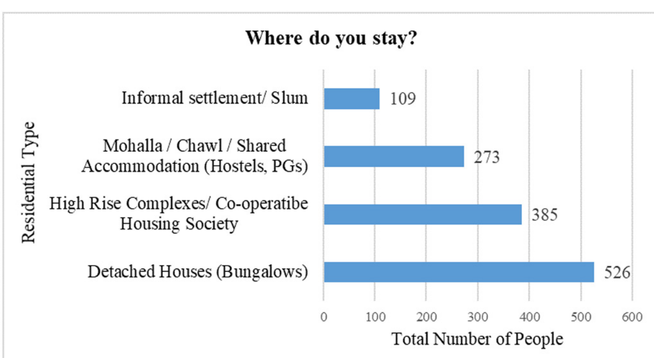


Fig. 8. Exposure based on residential type (n = 1293).

The study has re-iterated the characteristics of the COVID-19 pandemic as mentioned in [1] by showing strong correlation of total risk with age and co-morbidities. In terms of co-morbidities, hypertension followed by diabetes has appeared to be major factor in adding to the total risk. As per Sivasubramanian et al. [32], there is a high prevalence of hypertension, with almost one in every three Indian adults affected. In addition to it, smokers are found to be more at risk with a moderate correlation between smoking and total risk. This finding corroborates with the study in [27] which portrays smoking as a risk factor contributing to the COVID-19 fatalities. In terms of gender, males remain more susceptible than female in high risk category. Anxiety in general has appeared as a major cause of concern

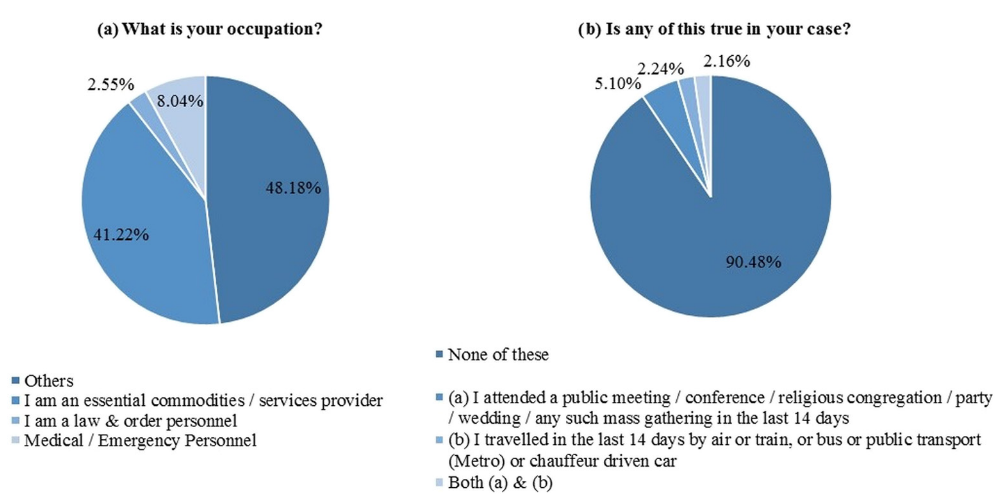


Fig. 9. (a): occupation type, (b): travel and public event attendance history (n = 1293).

Table 5
Pearson correlation analysis ($n = 1293$).

Variables	Strength of correlation	Pearson correlation coefficient
Age-group and Co-morbidities	Positive and moderate correlation	0.434
Age-Group and No disease	Negative relation with a moderate strength	−0.420
Age-Group and Total Risk	Positive and strong correlation	0.835
Wearing of mask and following of Social Distancing norm (Individual behaviour variables be1 and be4)	Positive and weak correlation	0.298
Washing hands and compliance of social distancing norms (Individual behaviour variables be2 and be4)	Positive and moderate correlation	0.364
Co-morbidities and Total Risk	Positive and strong correlation	0.678
Co-morbidities and hypertension	Positive and moderate correlation	0.418
Co-morbidities and diabetes	Positive and moderate correlation	0.400
Gender and Behaviour (be score - all four individual behaviour variables)	Negligible correlation	0.017
Age-Group and Behaviour	Negligible correlation	0.048
Gender and Health (health score accounting all variables of health factor)	Positive and moderate correlation	0.346
Total Risk and Health Score	Positive and moderate correlation	0.983
Smoking and Total Risk	Positive and moderate correlation	0.302
Social Policy Variables- Sp1 Effective Lockdown and Sp2 Community compliance of wearing mask and social distancing	Positive and moderate correlation	0.363
Social Policy Score and Behaviour Score	Positive and moderate correlation	0.266

and adequate mental health counselling measures are needed to be in place especially in areas where cases have been detected.

As the paper states, the COVID-19 Risk assessment tool goes beyond the medical symptoms and considers factors of individual behaviour and social policy. In this regard, it is observed that there is a weak correlation between individual behaviour and social policy. Also, there is weak correlation between individual behaviour of wearing mask and practicing social distancing. Cheng and Kwang [6] states the importance of social behaviour in contribution to the risk of contracting the disease as observed in the case of SARS. Thereby, a weak correlation between individual behaviour and social policy compliance depicts a gap in the governance and implementation mechanism. This implies that there is a need for more awareness generation among community. Since a major part of response of pandemic depends on culture and citizen behaviour [19], the decision-makers need to design targeted intervention policies for creating the risk preventive behaviour and increasing the community compliance of the social policy measures. The finding regarding the lower age group (0–9 years) being in moderate risk category depict that there is a need to educate children about touching the face without sanitizing their hands as they might do it more frequently than adults. Further, children specific risk communication means can be developed so as to ingrain the preventive behaviour. As noted in [33] people's behaviour is influenced by social norms: what they perceive that others are doing or what they think that others approve or disapprove of. Risk perception can be changed by promoting public messages reinforcing positive health-promoting norms[ibid]. Public knowledge of risk allows for change in perspective and more social compliance in terms of adoption of risk preventive behaviour. The interventions can focus on targeting well-connected individuals and making their behaviour change visible and salient for others to copy.

As only 8% people have responded from informal settlements, this depicts a wide gap in digital divide in the country. Many of the respondents living in informal settlements reflect the bottom most layer of the social and income structure. Inequalities in access to resources affect not only who is at greatest risk of infection, developing symptoms or succumbing to the disease, but also who is able to adopt recommendations to slow the spread of the disease. Such communities may be more likely to be wary about the public health information they receive, less willing to adopt recommended safety measures and potentially more susceptible to 'fake news'[ibid]. In this regard, community-oriented tools of risk awareness need to be more popularized so that risk communication reaches the last mile. Tashiro and Shaw [19] mentions a human-centric society where technology connects people and tries to reduce the barrier of digital divide. The COVID-19 Risk Assessment Tool is multi-lingual tool which helps the communities to access the advisory and understand the individual risk in a simplified way. This is particularly helpful for migrants who need to understand the risk in their own language. Citizens might also be wary of using the government supported tools and apps for the concerns of privacy. Lack of national data privacy laws and non-transparency in governance of such data collected are some of the issues flagged by people as part of resistance to use the Arogya Setu app of Government of India [34]. RIKA's COVID-19 Risk Assessment Tool addresses the concern by not collecting any personal data like mobile number or accessing the location history of the user.

Artificial intelligence has been used for emergency data management, especially for managing social networks and big data. The people are using digital technologies to support disaster management. Crowdsourcing is helping to add vital details to maps of disaster areas. Citizen science is becoming more popular and effective before, during, and after disasters. Grassroots or demand-driven innovation has been practiced in many countries in recent years. In this aspect, the COVID-19 Risk Assessment Tool presents itself as an innovative approach of using science and technology for enhancing community preparedness. The crowd-sourced data and maps generated allow the stakeholders like Government agencies and NGOs to plan the response and interventions. The Risk Assessment tool is flexible and it has a simple user-interface. This allows it to be contextualised to cater to any target community with specific need. This adaptability of the tool places it as a unique innovation coming from the citizen science approach. The two-way data interface in the form of feedback mechanism provides platform for participation of citizens in decision-making for the response strategies. As observed from findings, 51% people have marked for the need of new measures to control the pandemic. This paves way for a more participatory approach for the decision-makers in planning an intervention at the local level. To re-iterate Shaw et al. [1] the pandemic is global but the response is local, this tool allows for a more contextualised and community specific response.

6. Conclusion

While writing this paper, the number of affected cases in India is still on a rise while countries like Singapore, South Korea, China and a few other are expecting a second wave of pandemic. In this backdrop, the preventive measures need to be strengthened at all costs and citizen's behaviour as has been seen in South Korea and Japan is an important factors to break the chain. For a populous country like India, where it is difficult for the current health infrastructure to accommodate and treat an exponential increase number of the patients as had been seen also in Italy, China and United States of America for treatment, it is best to follow the preventive strategies. RIKA's COVID-19 Risk Assessment Tool can be used to reach the last mile community, ascertain the individual behaviour, social compliance and exposure factors in order to find out relevant areas of intervention and at the same time increase awareness generation among the community. As rightly pointed out by [4], the management of COVID-19 pandemic is interwoven within the global governance, technology and risk communication. This pandemic is witnessing a change in the social norm and a new normal is being established. This is also an opportunity for new innovative technologies to break the digital divide and increase the resilience of the most vulnerable communities through democratic information access and participatory decision-making to develop a local level response strategy.

CRediT authorship contribution statement

Ranit Chatterjee: Conceptualization, Methodology, Writing - original draft, Writing - review & editing. **Sukhreet Bajwa:** Formal analysis, Writing - original draft, Writing - review & editing. **Disha Dwivedi:** Formal analysis, Writing - original draft, Writing - review & editing. **Repaul Kanji:** Methodology. **Moniruddin Ahammed:** Investigation. **Rajib Shaw:** Conceptualization, Methodology, Writing - original draft, Writing - review & editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.pdisas.2020.100109.

References

[1] Shaw R, Kim, Y.-k., & Hua, J.. Governance, technology and citizen behavior in pandemic: lessons from COVID-19 in East Asia. Prog Disaster Sci. 2020;6. https://doi.org/10.1016/j.pdisas.2020.100090. accessed on: 24 April 2020.
[2] Kelland K, Nebehay S. WHO officials rethink epidemic messaging amid pandemic debate. Available at: . https://www.reuters.com/article/us-health-coronavirus-who-messaging-insi/who-officials-rethink-epidemic-messaging-amid-pandemic-debate-idUSKBN2101AY; 2020, 3 13. accessed on: 24 April 2020.
[3] WORLDOMETER. . https://www.worldometers.info/coronavirus/. Accessed on: 5 May, 2020.
[4] Zhang H. & Shaw R. Identifying research trends and gaps in the context of COVID-19 (under publication). accessed on: 24 April 2020.
[5] Hua J, Shaw R. Corona virus (COVID-19) "Infodemic" and emerging issues through a data Lens: the case of China. Int J Environ Res Public Health. 2020;17. https://doi.org/10.3390/ijerph17072309 Available at:. accessed on: 21 April, 2020.
[6] Cheng C, Kwang A. Psychosocial factors predicting SARS-preventive behaviors in four major SARS-affected regions. J Appl Soc Psychol. 2006;36(1):222–47 Available at: . https://doi.org/10.1111/j.0021-9029.2006.00059.x. accesssed on: 24 April, 2020.
[7] Vaishya R, Javaid M, Khan IH, Haleem A. Artificial intelligence (AI) applications for COVID-19 pandemic. Science Direct. 2020;14(4):337–9. https://doi.org/10.1016/j.dsx.2020.04.012 accessed on: 24 April, 2020.
[8] WHO. EP-Win Updates. Available at: . https://www.who.int/teams/risk-communication/epi-win-updates. accessed on: 25 April 2020.
[9] DeWit A, Djalante R, Shaw R. Building holistic resilience: Tokyo's 2050 strategy. Asia Pac J. 2020;18(7):1–15 Japan Focus. Available at: . https://apjjf.org/2020/7/DeWit.html. accessed on: 21 April, 2020.
[10] DiClemente R, Jackson J. Risk communication. International Encyclopedia of Public Health (Second Edition); 2017 Available from: . https://www.sciencedirect.com/referencework/9780128037089/international-encyclopedia-of-public-health accessed on: 24 April 2020.
[11] Bruinen De Bruin Yuri, Hakkinen Pertti, Lahaniatis Majlinda, Papameletiou Demosthenes, Pozo Carlos Del, Reina Vittorio, Engelen Jacqueline, Heinemeyer Gerhard, Viso Anne Catherine, Rodriguez Carlos, and Jantunen Matti (2007). Risk management measures for chemicals in consumer products: documentation, assessment, and communication across the supply chain. J Expo Sci Environ Epidemiol, 17, 55–66. Available at: doi:. https://doi.org/10.1038/sj.jes.7500587, accessed on: 24 April 2020.
[12] Barry JM. Pandemics: avoiding the mistakes of 1918. Nature. 2009;459:324–5 Available at: . https://doi.org/10.1038/459324a. Accesssed on: 24 April, 2020.
[13] Infermedica. Available at: . https://infermedica.com/covid19. accessed on: 26 April 2020.
[14] Health Engie. Available at: . https://healthengine.com.au/covid19/. accessed on: 26 April 2020.
[15] Henry Ford Health System. Available at: . https://www.henryford.com/services/infectious-diseases/conditions/COVID-19-coronavirus/coronavirus-assessment-tool. accessed on: 26 April 2020.
[16] Coronavirus (COVID-19) Self-Assessment Tool. Available at: . https://www.humandx.org/COVID-19/assessment. accessed on: 26 April 2020.
[17] Chaturvedi A. Top 10 popular smartphone apps to track COVID-19. Available from Geospatial World: . https://www.geospatialworld.net/blogs/popular-apps-COVID-19/; 2020, 4 18. accessed on: 24 April, 2020.
[18] Yang Jing, Zheng Ya, Xi Gou, Ke Pu, Zhaofeng Chen, Guo Qinghong, et al. Prevalence of comorbidities and its effect in patients infected with SARS-Cov-2: a systematic review and meta-analysis. Int J Infect Dis. 2020;94:91–5 Available at: . https://doi.org/10.1016/j.ijid.2020.03.017. accessed on 23 April, 2020.
[19] Tashiro A., & Shaw R. (2020). COVID-19 pandemic response in Japan: what makes initial flattening of the curve? (under publication). J Public Health Policy. accessed on: 24 April 2020.
[20] COVID-19 India. Available at: . https://www.mohfw.gov.in/. accessed on 5 May, 2020.
[21] All press release. Press Information Bureau, Government of India: Available at: . https://pib.gov.in/allRel.aspx, accessed on: 26 April, 2020.
[22] Susana Pallares, EvaTrinidad Gomez, Africa Martinez, Miguel Jordan Manuel. The relationship between indoor and outdoor levels of PM10 and its chemical composition at schools in a coastal region in Spain. Science Direct. 2019;5(8). https://doi.org/10.1016/j.heliyon.2019.e02270 Available at:. accessed on: 4 May 2020.
[23] Lin Yu-Hsuan, Liu Chun-Hao, Chiu Yu-Chuan (2020). Google searches for the keywords of "wash hands" predict the speed of national spread of COVID 19 outbreak among 21 countries. doi:. https://doi.org/10.1016/j.bbi.2020.04.020 accessed on: 4 May 2020.
[24] Pearson Correlation Coefficient. Statistics solutions. Available at: . https://www.statisticssolutions.com/pearsons-correlation-coefficient/. accessed on: 4 May 2020.
[25] Telecomlead. Available at: . https://www.telecomlead.com/telecom-statistics/indias-active-mobile-users-reached-1026-37-mn-trai-89104. accessed on: 15 May, 2020.
[26] Trai. Telecom Regulatory Authority of India. Available at: . https://trai.gov.in/sites/default/files/PR_No.13of2019.pdf. accessed on: 15 May, 2020.
[27] ECDC. Coronavirus disease 2019 (COVID-19) pandemic: increased transmission in the EU/EEA and the UK – seventh update. Stockholm: European Centre for Disease Prevention and Control; 2020 Available from: . https://www.ecdc.europa.eu/sites/default/files/documents/RRA-seventh-update-Outbreak-of-coronavirus-disease-COVID-19.pdf.
[28] Michele Acuto. COVID-19: lessons for an urban(izing) world. Science Direct. 2020;2(4). https://doi.org/10.1016/j.oneear.2020.04.004 Available at:. accessed on 15 May, 2020.
[29] Divo J. Miguel, Martinez H. Carlos, Mannino M. David (2014). Ageing and the epidemiology of multimorbidity. doi:. https://doi.org/10.1183/09031936.00059814, accessed on 15 May, 2020.
[30] Bruin de Yuri Bruinen, Lequarre Anne-Sophie, McCourt Josephine, Clevestig Peter, Pigazzani Filippo (2020). Initial impacts of global risk mitigation measures taken during the combatting of the COVID-19 pandemic. doi:. https://doi.org/10.1016/j.ssci.2020.104773, accessed on 15 May, 2020.
[31] Laura Silver, Aaron Smith, Courtney Johnson, Kyle Taylor, Jingjing Jiang, Monica Anderson, et al. Mobile connectivity in emerging economies. Available at: . https://www.pewresearch.org/internet/wp-content/uploads/sites/9/2019/03/PI_2019.03.07_Mobile-Connectivity_FINAL.pdf; 2019. accessed on 15 May, 2020.
[32] Ramakrishnan Sivasubramanian, Zachariah Geevar, Gupta Kartik, Rao J Shivkumar, Mohanan PP, Venugopal K, et al. Prevalence of hypertension among Indian adults: results from the great India blood pressure survey. Indian Heart J. 2019 Science Direct. Available at: . https://doi.org/10.1016/j.ihj.2019.09.012. Accessed on 15 May, 2020.
[33] Bavel Jay J. Van, Baicker Katherine, Boggio Paulo S., Capraro Valerio, Cichocka Aleksandra, Cikara Mina, Crockett Molly J., Crum Alia J., Douglas Karen M., Druckman James N., Drury John, Dube Oeindrila, Ellemers Naomi, Finkel Eli J., Fowler James H., Gelfand Michele, Han Shihui, Haslam S. Alexander, Jetten Jolanda, Kitayama Shinobu, Mobbs Dean, Napper Lucy E., Packer Dominic J., Pennycook Gordon, Peters Ellen, Petty Richard E., Rand David G., Reicher, Stephen D., Schnall Simone, Shariff Azim, Skitka, Linda J., Smith Sandra Susan, Sunstein Cass R., Tabri Nassim, Tucker Joshua A., van der Linden, Sander, van Lange, Paul, Weeden Kim A., Wohl Michael J. A., Zaki Jamil, Zion Sean R., Willer Robb, Available at: doi:. https://doi.org/10.1038/s41562-020-0884-z, accessed on 15 May, 2020.
[34] The Indian Express. Centre must address privacy concerns, and ensure greater transparency on Aarogya Setu. Available at: . https://indianexpress.com/article/opinion/columns/aarogya-setu-app-supreme-court-coronavirus-covid-6405175/. accessed on 15 May, 2020.
[35] Kennedy RA, ... Sonnenfeld G. Effects of sex and gender on adaptation to space: immune system. J Womens Health. 2014;23(11):2014.
[36] UNDP report (2020) Innovative Responses To Covid-19: Collection Of Approaches From The Republic Of Korea.

Other References for tool development

COVIDSafe. Accessed from . https://www.health.gov.au/resources/apps-and-tools/covidsafe-app; 2020. accessed on 15th May 2020.
Lele D. Risk assessment: a neglected tool for health, safety, and environment management. Indian J Occup Environ Med. 2012;16(2):57–8 Available at: . https://doi.org/10.4103/0019-5278.107064. accesssed on: 24 April 2020.
WHO. Risk communication. Available at: World Health Organisation: . https://www.who.int/risk-communication/background/en/, accessed on: 24 April, 2020.

WHO. Health emergency and disaster risk management framework. Available at: . https://www.who.int/hac/techguidance/preparedness/health-emergency-and-disaster-risk-management-framework-eng.pdf?ua=1; 2019.

Shaw R. Thirty years of science, technology, and academia in disaster risk reduction and emerging responsibilities. Int J Disaster Risk Sci. 2020. https://doi.org/10.1007/s13753-020-00264-z Available at:. accessed on: 22 April, 2020.

Coronavirus. Coronavirus disease 2019 (COVID-19) pandemic: increased transmission in the EU/EEA and the UK – seventh update. Stockholm: European Centre for Disease Prevention and Control; 2020 Available at . https://www.ecdc.europa.eu/sites/default/files/documents/RRA-seventh-update-Outbreak-of-coronavirus-disease-COVID-19.pdf.

Person B, Sy F, Holton K, Govert B, Liang A. Fear and stigma: the epidemic within the SARS outbreak. Emerg Infect Dis. 2004;10(2):358–63 Available at: . https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3322940/pdf/03-0750.pdf.

Lee S, Lee S-S, Fung C S-c, Kwok KP-s. Public attitudes toward SARS and their implications for societal preparedness for other emerging infections. Soc Med. 2008;3(2):57–63. https://www.medicinasocial.info/index.php/socialmedicine/article/view/100/427.

Tran, J., Norton, R., Conrad, N., Rahimian, F., Canoy, D., Nazarzadeh, M., & Rahimi, K. (2018). Patterns and temporal trends of comorbidity among adult patients with incident cardiovascular disease in the UK between 2000 and 2014: a population-based cohort study. doi:. https://doi.org/10.1371/journal.pmed.1002513

Global COVID-19 case fatality rates. (2020, 3 17). The Centre for Evidence-Based Medicine develops, promotes and disseminates better evidence for healthcare. Available at: . https://www.cebm.net/COVID-19/global-COVID-19-case-fatality-rates/.

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Invited ViewPoint

Building resilience against biological hazards and pandemics: COVID-19 and its implications for the Sendai Framework

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ABSTRACT

2020 has become the year of coping with COVID-19. This year was to be the “super year” for sustainability, a year of strengthening global actions to accelerate the transformations required for achieving the 2030 agenda. We argue that 2020 can and must be a year of both. Thus we call for more utilisation of the health-emergency disaster risk management (Health-EDRM) framework to complement current responses to COVID-19 and the patent risk of similar phenomena in the future. To make our case, we examine current responses to COVID-19 and their implications for the SFDRR. We argue that current mechanisms and strategies for disaster resilience, as outlined in the SFDRR, can enhance responses to epidemics or global pandemics such as COVID-19. In this regard, we make several general and DRR-specific recommendations. These recommendations concern knowledge and science provision in understanding disaster and health-related emergency risks, the extension of disaster risk governance to manage both disaster risks and potential health-emergencies, particularly for humanitarian coordination aspects; and the strengthening of community-level preparedness and response.

Contents

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1. Introduction: SFDRR and Health Emergency and Disaster Risk Management (Health-EDRM)

COVID-19 has rapidly morphed into an unprecedented health, economic and geopolitical crisis. It surely underscores the imperative of accelerating the integration of multiple global policy frameworks, not least those at the centre of the 2030 Agenda. Prior to the emergence of COVID-19, the UN Secretary General had positioned 2020 as the "super year" for action on sustainability (UN, 2020). The Sustainable Development Goals (SDGs), Paris Agreement on Climate Change, and the New Urban Agenda, alongside the SFDRR were all adopted in 2015–2016. March 18th, 2020 marks the fifth anniversary of implementation of the 2015–2030 Sendai Framework for Disaster Risk Reduction (SFDRR). The SFDRR aims to enhance national and community capacity to cope with disaster risks. It emphasizes a comprehensive approach, to address multiple hazards (technological, biological and environmental) that impact at different scales, frequency, and intensity (UNISDR, 2015).

Human health cross-cuts all the global frameworks. The SFDRR explicitly includes epidemics and pandemics among biological hazards (UNISDR, 2015) [1–3]. Moreover, SDG 3 is devoted to "good health and well-being", with an emphasis on "early warning, risk reduction and management of national and global health risks" (UN, 2015). For its part, the Paris Agreement and the Intergovernmental Panel on Climate Change Assessment Report highlights that climate change exacerbates health risks including pandemics (see e.g. [4,5]). The recently edited book by Chan and Shaw [6] on Public Health and Disasters is timely since it highlights the progress and importance of the Health-EDRM framework adopted by the WHO in 2019. Health-EDRM refers to the "systematic analysis and management of health risks, posed by emergencies and disasters, through a combination of (1) hazard and vulnerability reduction to prevent and mitigate risks, (2) preparedness, (3) response and (4) recovery measures" (WHO 2019). Health-EDRM is thus an umbrella term, which the WHO uses to refer to the broad intersection of health and disaster risk management (DRM). It also comprises such areas as emergency and disaster medicine, bolstered health systems and resilience, disaster risk reduction, humanitarian response, and community health resilience [7].

Against the backdrop of still-worsening COVID-19 impacts, this paper discusses resilience building for pandemics and related biological hazards. We examine ongoing efforts to respond to COVID-19 and these efforts' implications for the Sendai Framework. Our analysis reveals specific areas of rapid response to COVID-19. But we find lamentably few actions by DRR-related organisations, in spite of the SFDRR's call for building resilience to biological hazards. Moreover, the current WHO-led coordinated response reveals little implementation of the WHO Thematic Platform for Health-EDRM adopted in 2019. Existing mechanisms and strategies for disaster resilience, such as those detailed in the SFDRR, offer concrete means to respond effectively to epidemics and even global pandemics such as COVID-19. We thus put forward general and DRR-specific recommendations for short and long-term resilience.

This viewpoint is structured as follows. In the introduction, we present the motivation for the paper along with brief reviews of the recent progress of SFDRR and Health-EDRM implementation. Section 2 reviews global responses to COVID-19 complemented with discussion of responses by agencies related to DRR. Section 3 elaborates our recommendations supported with examples and cases.

2. Responses to COVID-19 from global to national level

This section briefly investigates current responses to COVID-19 from the global, regional to national levels. We do not engage in an exhaustive review of approaches at any level, and instead use representative cases to demonstrate our key argument. That is, we focus our analysis on whether a given level - global, regional or national - includes significant input from DRR-related agencies. To us, the evidence suggests that COVID-19 has yet to elicit early and rapid action from the DRR-related organisations. We believe this passivity belies the SFDRR's call for building resilience against all hazards, including biological hazards.

2.1. Global level

The global level of response includes the UN's COVID-19 communications wherein the Secretary General has called for "coordinated, decisive, and innovative policy action" on COVID-19. The World Health Organization, under Director-General Dr. Tedros Adhanom Ghebreyesus, leads the coordinated response for COVID-19. On the 11th of March, the DG announced that COVID-19 is a global pandemic. As of March 20, WHO's front page focuses on the COVID-19 outbreak (https://www.who.int/emergencies/diseases/novel-coronavirus-2019) (Fig. 1). The WHO has called for at least US$675 million to fund critical response efforts in countries most in need of help through April 2020.

The above and other content indicate that the WHO (2019) framework on Health Emergency and Disaster Risk Management (Health-EDRM) has no apparent role in the current response strategies. Certainly there is no mention of disaster at all within the WHO Coronavirus disease (COVID-19) technical guidance, particularly on the COVID-19 Strategic Preparedness and Response Plan, regarding Operational Planning Guidelines to Support Country Preparedness and Response (WHO, 2020).

Also at the global level, the UN Office for DRR [8] issued a press release on the 12th of March 2020 urging disaster management agencies to prioritize biological hazards. The UNDRR asked national disaster management agencies to continue with the development of their preparedness and response capacities to include health emergencies as a top priority, alongside earthquakes, floods, storms and other natural hazards (UNDRR, 2020). It

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also highlighted the importance of silo-breaking in disaster prevention and management, notably the silos between disaster management and health workers. The UNDRR reiterates that the Sendai Framework emphasizes the need for resilient health systems and the integration of disaster risk management into health care provision at all levels. After all, Sendai turns the focus from disaster response and management to preparedness, surveillance and disaster risk management in the health context (UNDRR, 2020). Yet it is not clear whether COVID-19 is leading to collaboration between the WHO and the UNDRR.

We appraise the speed and scale by which COVID-19 response funds are made available. International funding organisations, regional government bodies and private entities have proposed major financial measures. The International Monetary Fund (IMF) made $50 billion in loans available to deal with the coronavirus, including $10 billion of zero-interest loans to the poorest IMF member countries (IMF, 2020). The EU Commission President Ursula von der Leyen announced a €25 billion coronavirus investment fund for the health care sector, labour market and SMEs (EU, 2020). The World Bank Group increases COVID-19 Response to $14 billion to help sustain economies and protect jobs. The Asian Development Bank (ADB) announces $6.5 billion initial response to COVID-19 pandemic (ADB, 2020). The UN announced $15 million dollars from the UN's Central Emergency Fund to help fund global efforts to contain the spread of the COVID-19 coronavirus, particularly vulnerable countries with weak health care systems (UN, 2020). It is important to note that in the SFDRR, investment and finance are at the core of Sendai Framework, in terms of the resilience investment needed for countries and communities.

2.2. Regional level

We separate the regional level into Europe, Asia, and Africa. Concerning the former, the European Commission (EC) leads the planning and implementation of European Union (EU) strategy, its role in setting priorities, and its implementation through EU policy. A dedicated website is https://ec.europa.eu/info/live-work-travel-eu/health/coronavirus-response_en. The EU has established a common European response to the outbreak of COVID-19, focusing on public health sectors and socio-economic impact particularly mobility and economy in the **European Union** (EU, 19th March 2020). Italy is the most severely impacted country in the EU. The EC support for the Sendai Framework identifies health as one of the issues interlinked with DRR (EC Web, 2020). Yet it is unclear whether the EU response to COVID-19 features coordinated involvement by DRR-related agencies and mechanisms. The opportunity for integration may be possible through the Integrated Political Crisis Response (IPCR). The IPRC provides a flexible crisis mechanism for supporting the presidency of the Council of the European Union in dealing with major natural or man-made cross-sectorial disasters, as well as acts of terrorism. The IPCR works through common Monitoring and Information-sharing (EU, 2016).

In Asia, the response of the Association of Southeast Asian Nations, or **ASEAN**, is instructive. The ASEAN was established on 8 August 1967 in Bangkok, Thailand, with the signing of the ASEAN Declaration (Bangkok Declaration) by Indonesia, Malaysia, Philippines, Singapore and Thailand. The ASEAN now includes 10 member countries and coordinates regional action. Concerning COVID-19, ASEAN has issued ASEAN Health Sector Efforts in the Prevention, Detection and Response to Coronavirus Disease 2019 (ASEAN, 2020). Guided by the ASEAN Post-2015 Health Development Agenda (APHDA) and its Governance and Implementation Mechanism (GIM), the ASEAN Health Sector Cooperation deployed and operationalized the established and existing health mechanisms for technical exchanges, information sharing, and updates on policy-related measures in responding to COVID-19. ASEAN specialised agencies involved are the ASEAN Emergency Operations Centre Network for public health emergencies (ASEAN EOC Network), ASEAN Senior Officials for Health Development (SOMHD) of ASEAN and China, Japan and Republic of Korea (Plus Three Countries), and ASEAN BioDioaspora Regional Virtual Centre (ABVC) (ASEAN, 2020). There is no indication that the ASEAN Coordinating Centre for Humanitarian Assistance on disaster management (AHA Centre) is involved in the ASEAN's response to COVID-19. AHA Centre is an inter-governmental organisation which aims to facilitate cooperation and coordination among ASEAN Member States and with the United Nations and international organisations for disaster management and emergency response in ASEAN region. Leadership is beyond the mandate of the AHA Center (see https://ahacentre.org/about-us/). But its plethora of existing mechanisms can and should be used. These mechanisms include the Emergency Operations Centre (EOC), the Standard Operating Procedure for Regional Standby Arrangements and Coordination of Joint Disaster Relief and Emergency Response Operations (SASOP), the ASEAN Joint Disaster Response Plan (AJDRP), the Disaster Emergency Logistics System for ASEAN (DELSA), the Emergency Response and Assessment Team (ERAT), the ASEAN Regional Disaster Emergency Response Simulation Exercise (ARDEX), ASEAN-ERAT (ASEAN-Emergency Response and Assessment Team) and the AHA Centre Executive (ACE) Programme (REF). Globally, the ASEAN region is one of the most vulnerable to disasters, and the AHA Center has been praised for its role in strengthening DRM in the region (e.g. [9,10]). These competencies surely ought to be deployed in addressing the rapid emergence of COVID-19 as well as building resilience against a repeat.

Another item of note is the South Asian Association for Regional Cooperation (SAARC). **SAARC** is the regional intergovernmental organisation and geopolitical union of states in South Asia. Its member states are Afghanistan, Bangladesh, Bhutan, India, the Maldives, Nepal, Pakistan and Sri Lanka. The SAARC leaders held a video conference on 15 March 2020 to discuss measures to contain the spread of COVID-19 in the region (GoI, 2020). India's Prime Minister initiated the conference, calling upon SAARC leaders to work collectively to fight the spread of the pandemic in the region. India called for the creation of a COVID-19 Emergency Fund, with voluntary contributions from all Member States. India itself pledged US$ 10 million as an initial contribution. There is no further information available. To be sure, SAARC developed a Comprehensive Framework on Disaster Management and Disaster Prevention in 2005 and established a number of SAARC centres, chiefly the SAARC Centre for Disaster Management and Preparedness (SDMC) to implement the framework. Yet progress to build the DRM capacities of South Asian states through regional cooperation has been slow (Brookings-LSE, 2015). There have long been doubts about SAARC's effectiveness (e.g.[11]) and readiness [12], so it may not be up to the task of coordinating a regional response to COVID-19.

In Africa, WHO-African region coordinates the response, with its latest Situational Report announced as of 18 March 2020. A total of 345 confirmed COVID-19 cases have been reported across 27 countries in the region (WHO-AFRO, 2020). Financially, Melinda and Gates' foundation issued USD 115 million in aid for COVID-19 with USD 100 million pledged to Africa and South Asia.

2.3. National level

It is very clear that responses to COVID-19 centre on actions at the global and national level. We organise the review by the regions.

2.3.1. Asia

The first known case of COVID-19 emerged in the **Chinese** city of Wuhan on December 12,019 and was deemed an emergency in the third week of January 2020. WHO declared COVID-19 (the “new coronavirus”) a Public Health Emergency of International Concern (PHEIC) on 31st of January 2020, and finally a pandemic on 11th March 2020. Based on Chinese newspaper, social media and other digital platform data, Hua and Shaw [13] analyse the timeline of key actions taken by the government and people over three months in five different phases: the very early phase (up to 31st of December 2019), the investigation phase (up to 20th January 2020), the early identification phase (up to 31st of January), the criticism, agony and depression phase (up to 14th February), and lastly the positive preventive and curative control phase (up to 29th February). Their analysis details the initial delay in responding, but also highlights key factors in China's efforts to combat COVID-19. These factors include

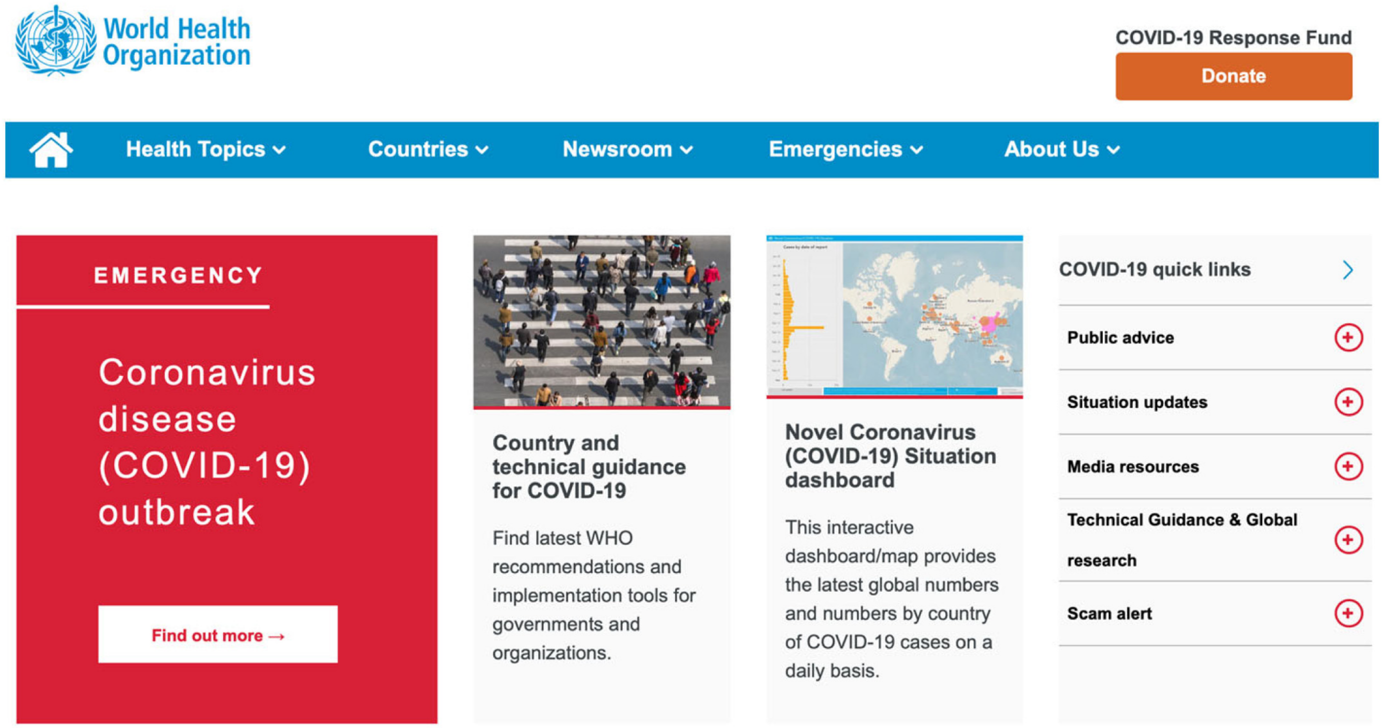

Fig. 1. Frontpage of WHO website on March 19th, 2020 (WHO, 2020).

strong governance, strict regulation, strong community vigilance and citizen participation, and wise use of big data and digital technologies.

Japan came under the spotlight in January 2020, when the luxury cruise ship Diamond Princess was docked in Yokohama, and symptoms of COVID-19 were detected in several persons. Complex issues of governance and strict regulation complicated the initial response, leading to a wide spread of the COVID-19 among the passengers and crew. Subsequently, COVID-19 began being reported in persons returning to Japan from abroad, mainly from China. The Hokkaido region is particularly affected. An epidemic cluster approach has marked the Japanese government's response, limiting testing. A strict government response followed, including school closures from early March, telework from home, flexible working time to avoid crowded trains, and an epidemic cluster approach. Communities and people followed this "request" from the government (which was not compulsory) apparently limiting the spread of COVID-19 and the number of deaths. Thus, the combination of government request and strong self-discipline within people and communities has evidently led to desirable results. The dedicated website http://japan.kantei.go.jp/index.html provides timely updates from the Prime Minister, with Japan having passed two packages of small business loans, one $4.6 billion package in February, and a $15 billion one on March 11, 2020.

In sharp contrast, **South Korea** was a surprise case of sudden high increase in affected people and high number of deaths (over 9,000 cases). Several cases of community spread, notably from religious organisations, which went out of control. However, through a strict screening and testing system, aided with advanced technology, South Korea was able to bring down the number of affected people as well as number of deaths. The country allocated more than $13 billion in emergency funds to stoke economic activity.

Taiwan, on the other hand, used 2003 SARS experience to prepare from the beginning through strict countermeasures as well as big data analysis of people's movement and thereby identifying the possible areas of spread of COVID-19.

Singapore is another case where an initial surge was observed in the number of affected people. The country took strict regulatory measures for quarantine, tracing infected people's movement. These measures succeeded in significantly limiting the number of newly infected people. Singapore has set aside 5.6 billion Singapore dollars ($4.02 billion) in the coming year to help businesses and households.

Other ASEAN countries, including **Indonesia**, provide a promising example of integrating Health-EDRM. The Indonesian COVID-19 task force (*Gugus Tugas Percepatan Penanganan COVID-19*) has been formed to coordinate the national COVID-19 response. A single coordinated source of information in Indonesia is presented through its dedicated website www.covid19.go.id. This task force is led by the chief of the National Disaster Management Agency (BNPB), General Doni Monardo. Beyond that, it remains unclear whether there is a deeper coordination of different agencies/ministries, and whether this extends to response mechanisms from the national, provincial and local governments. The Indonesian government has prepared a budget of Rp 1 trillion, or around $70 million, to be channelled through the Health Ministry to try to contain the Covid-19 outbreak and care.

India, with the second largest population in the world, has taken early precautionary measures through travel and visa bans on foreigners from certain countries, mandatory health checks and self-quarantine for 14 days. The Indian Prime Minister, in a national address, encouraged citizens to observe self-curfew and community vigilance at the initial stage. These actions appear to have limited community spread in this highly populated country. While PM Modi has announced India's contribution to SAARC, information for the national fund is not available.

Iran, on the other hand, has seen a drastic rise in the number of affected people and deaths, the largest in Asia (outside China). The Iranian outbreak has mainly been attributed to a lack of initial responses by the government, limited public awareness of the risk of contagion, and lack of mandatory self-quarantine. Public attitudes are a key issue underlying Iran's high death rate (roughly 10% of globally infected people, as compared to China's 30%).

2.3.2. Europe

In Europe, **Italy** is the worst hit with a comparatively high percentage of deaths among the infected. This outcome has been attributed to lack of regulation and testing, which prompted the community spreading. Gradually, stricter government regulation and vigilance systems have been implemented and enforced, along with social distancing among the people. However, the open border among the EU countries has helped in spreading the disease to Spain, France, Germany and Switzerland, as well as to the UK. The European Union (EU) has been surprisingly slow in coordinating a response to the outbreak. High rates of infection and deaths eventually prompted the European Commission to coordinate a common European response to the outbreak. The response includes resolute action to reinforce the country's public health sectors and mitigate the socio-economic impact in the European Union. In terms of funding, the French announced $49 billion, Italy announced a $28 billion plan on March 11 to be divided over two separate spending packages, while the UK announced a £5 billion COVID-19 fund (UKGov, 2020).

2.3.3. North America

The impact on North America was delayed and the threat taken quite lightly. The most significant action for some time was airlift of infected passengers from the cruise ship in Japan in February 2020. However, no travel ban was imposed. This policy resulted in free travel to Europe and Asian countries, leading to a sudden increase in the number of infected people in both Canada and the USA. Once WHO declared COVID-19 a pandemic in the second week of March, the **USA** also declared a national emergency, although some of the states declared state emergency at an earlier stage. Travel bans have since been imposed and screening, testing, mandatory quarantine practices are in place. The US government's website on COVID-19 is https://www.usa.gov/coronavirus. US President Trump signed an $8.3 billion spending bill, currently called "Phase One" of stimulus efforts, and up to $50 billion in aid to states, cities, and territories (USAGov, 2020).

In **Canada**, the Prime Minister convened an Incident Response Group on coronavirus, which has been meeting since the end of January. On March 5, he created a Cabinet Committee on the federal response to the coronavirus disease (COVID-19). Chaired by the Deputy Prime Minister and vice-chaired by the President of the Treasury Board, the committee meets regularly to ensure whole-of-government leadership, coordination, and preparedness to limit the health, economic and social impacts of the virus. The Canadian federal government released $1.1 billion in emergency response, with a larger fiscal stimulus planned (Gov of Canada, 2020).

In summary, countries took dramatically different approaches in managing the pandemic. The variation is marked by prior experiences and preparation, early reinforcement of strict vigilance, testing and isolation, late law enforcement, strong vs weak public awareness, self-restraint, commitments, and other factors. Some aspects of risk perception, awareness and response is a cultural issue, and powerfully linked to the socio-economic structure of the country and community. But in a strongly interconnected world, there surely needs to be a global standard and protocol for regional and national response. It is imperative to build mechanisms that decrease risks of infection and enhance community safety and resilience.

3. Recommendations on how current strategies for disaster resilience can contribute to responses to COVID-19

In this section, we put forward some recommendations on how current strategies for disaster resilience can contribute to responses to COVID-19. These are grouped into DRR-related health emergencies and recommendations in general.

3.1. General responses and societal adjustments

3.1.1. Legal aspects

There is an urgent need for global protocols, agreed and signed by the governments, to respond to global pandemic. A global pandemic is not merely a health issue, but also demonstrates a profound influence on the global economy. The lack of science-based decisions, resort to ad-hoc travel bans, and other uninformed and uncoordinated responses, worsened this pandemic both as a health crisis and an economic crisis.

3.1.2. Health and science aspects

It is imperative to strengthen information sharing and other coordinating mechanisms for health-related humanitarian issues. This includes sharing examples and experiences of preventive and treatment systems, new vaccine and preventive medicine information, means to protect the community from spreading through breaking the line of infection, and also basic awareness on sanitation. Future complexities and uncertainties on global health, along with environmental and societal changes will only increase in the future. The scientific methodologies to deal with uncertainties are being developed and should be utilised further in decision making. As stated in a March 17 editorial in Nature, it is critical to "Follow World Health Organization advice, end secrecy in decision-making and cooperate globally" [14].

3.1.3. Lifestyle aspects

First, good hygiene and a robust immune system are key to coping with any virus, and COVID-19 is no exception. Thus healthy lifestyles are prominent in enhancing resilience. Also, telework, the use of AI and other new technologies for work which can be done remotely needs to be promoted. These measures are consistent with emergent means of collaborating and producing science. These include working from home, collaborating online, online meeting and teaching, social media engagements by scientists, and engagement of social science. This diffusion of cooperation can also help behavioural science understand societal responses, foster risk communication experts, science-policy advice.

3.1.4. Learning from prior experiences makes a difference

Some countries and regions such as Singapore, Vietnam, Taiwan learned from the bitter experience of SARS of 2003. The recent past incentivised them to act promptly and no doubt inclined their citizens to cooperate, which paid off in reducing COVID-19's spread.

3.2. DRR-specific recommendations

3.2.1. Stronger knowledge and science provision in understanding disaster and health-related emergency risks

Disaster Risk assessment is a standard approach in DRR. Core methodologies for disaster risk assessment include hazard and vulnerability assessment. These methods can be utilised for COVID-19 risk assessment. In addition, the health sciences should be more involved in the community of disaster risk management, to advance our understanding of outbreaks and pandemics, the health impacts of all hazards, and improve data collection [15]. Science is recognised especially in modelling disease spread, data on affected people, and the rush for vaccines. Open data, Open Science and Open Map are being advocated. Existing spatial and remote sensing capacity for disaster can be used for mapping pandemics. The UN-SPIDER (Space-based Information for Disaster Management and Emergency Response) knowledge portal recognises epidemics as a source of hazard. The existing regional tsunami early warning systems can also be tasked for health-related emergencies. The systems include the Pacific Tsunami Warning Center (PTWC); the Indian Ocean Tsunami Warning System (IOTWS); and the North Eastern Atlantic, the Mediterranean and connected Seas (NEAMTWS). There is strong recognition for integration on DRR and CCA and appropriate adaptation can greatly reduce the health burden resulting from climate change and disasters [16]. The Sendai Framework takes an interconnected and pluralistic approach to understanding risk (UNDRR, 2019). The nature of current risks is complex and systemic, and can also be compound, interconnected, infracting and cascading risks [17]. Natural, technological and biological hazard disasters can occur in these fashions, as shown in the triple disasters of earthquake, tsunami and nuclear power plant failure in March 11, 2011 in Japan. Countries like Japan, or Indonesia, despite having to respond to current COVID-19, they also need to be ready should an earthquake or tsunami occur.

3.2.2. Mobilise existing disaster risk governance structure to manage disaster risk and potential health-emergencies

Multi-stakeholder engagements have been established, especially in disaster vulnerable countries. The same engagements can be utilised for addressing pandemic risks. One key agency is the International Federation of Red Cross and Red Crescent Societies (IFRC). The IFRC combines a wealth of knowledge on disaster risk reduction, with expertise in fighting the spread of diseases, combat discrimination and violence, and promoting human rights and assistance for migrants. For example, the IFRC issued an Appeal for Global COVID-19 Outbreak, and the IFRC, UNICEF and WHO issued new guidance to help protect children and schools from transmission of the COVID-19 virus (IFRC, 19 March 2020).

3.2.3. Utilise existing disaster coordination mechanisms at regional level to inform epidemic response

The regional bodies like ASEAN, SAARC, European Union (EU) need to enact regional protocols, coupled with information portals on pandemic risk. Traffic is quite high within the region, especially among countries with land borders. Thus proper protocol on human movement information sharing is required. The information sharing needs to be open and transparent, which enhances safer regional, cross border as well as global movement.

3.2.4. Understand COVID-19 economic implications and resilience

COVID-19 and its effects afford ample evidence of the imperative of bringing health into DRR. The economic fall-out from COVID-19 appears to be profound, at least $20 trillion in a few short weeks, and may exceed the 2008–2009 Great Recession. The direct costs of COVID-19 travel bans, social distancing, and other responses are merely one aspect. Far more devastating is the uncertainty that has gripped capital markets. Declining economic activity and large drops in capital markets have a mutually reinforcing impact, undermining the capacity of heavily indebted businesses and households to cover their debts. Uncertainty is the primary driver of such crises, and stems in large measure from lack of close coordination and science-based decision-making. Were there more certainty, households, investors and other economic agents would be less inclined to panic. COVID-19 appears certain to become a very costly lesson that DRR does indeed save many more multiples in avoided costs than its initial investment. An additional point in this regard is that health is a critical infrastructure. The resilience of critical infrastructure is well identified in DRR literature (e.g. [18,19]). Resilience is fostered not just by science-based decisions and coordination, but also via redundancy to ensure buffer capacity when a particular system collapses [20]. Disaster-illiterate economic policy tends to see redundancy as inefficiency. But in order to cope with COVID-19 and alleviate - if not prevent - future emergencies, supply chains for at least some critical items need to be more local. In tandem, governments and private businesses will have to broaden their crisis planning to ensure timely availability of items essential to limiting pandemic risks.

3.2.5. Prepare inclusive early recovery plans

At present, the data suggest that in some countries, including China, Korea, Japan, and a couple of other Asian countries, the peak of the COVID-19 may be over. It is imperative to continue taking precautions, including screening, isolation of suspected cases and social distancing. However, it is also important to start developing early recovery planning, which needs to be gender and disability inclusive. The socio-economic fall-out from this crisis is already high, and quite literally rising by the day. Concerns about preventing a protracted global recession, if not outright depression, are leading to focused intervention in capital markets and other areas. Aviation, energy, hotels, and other concerns that appear - to their investors and to policymakers - to be too big to allow to fail seem about to be given relief. Yet pandemic risks increase when general community health and well-being weaken. Thus it is critical that measures also be taken to identify the most vulnerable and include them in recovery packages.

3.2.6. Strengthen community-level preparedness and response

Methods from Community-based DRM can be used for COVID risk assessment. Community-based disaster preparedness and management [21,22] is crucial in reducing disaster deaths and losses. The last mile approach in disaster EWS, where community networks, communication systems, can be utilised for pandemic EWS at the community level. In disaster literature, risk perception strongly influences willingness to prepare for emergencies. Social linkages in communities may play an important role in focusing risk perceptions [23], while disaster type, gender, and previously experienced disasters are good predictors of victims' attitudes toward natural disasters [24].

In summary, we have examined current and unfolding responses to COVID-19 and their implications for the Sendai Framework. Core to our argument are strategies for resilience building against biological hazards and pandemic. We reiterate our assertion that there is a lack of early and rapid actions from the DRR-related organisations, despite the SFDRR's call for building resilience including from biological hazards. The SFDRR's ultimate goal is a substantial reduction of risk and losses, coupled with laying the essential foundations for rapid and sustained recovery and sustainable development. We hope the evidence we have added shows the crisis of COVID-19 could be used to make 2020 a "super year" of great progress on these goals.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

References

[1] **Aitsi-Selmi A, Murray V. Protecting the health and well-being of populations from disasters: health and health care in The Sendai Framework for Disaster Risk Reduction 2015–2030. Prehospital and Disaster Medicine 2016;31(1):74–8 [A set of papers were written by the authors outlining health consideration in the SFDRR].
[2] Aitsi-Selmi A, Egawa S, Sasaki H, Wannous C, Murray V. The Sendai framework for disaster risk reduction: renewing the global commitment to people's resilience, health, and well-being. International Journal of Disaster Risk Science 2015;6(2):164–76.
[3] **Chan EY, Murray V. What are the health research needs for the Sendai Framework? The Lancet 2017;390(10106):e35–6 [The authors have been influential in advocating for health consideration in the SFDRR].
[4] **IPCC, 2018: Global warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty [V. Masson-Delmotte, P. Zhai, H. O. Pörtner, D. Roberts, J. Skea, P.R. Shukla, A. Pirani, W. Moufouma-Okia, C. Péan, R. Pidcock, S. Connors, J. B. R. Matthews, Y. Chen, X. Zhou, M. I. Gomis, E. Lonnoy, T. Maycock, M. Tignor, T. Waterfield. [in press, this is the IPCC publication dedicated on impacts of 1.5 and 2, as outlined in the Paris Agreement].
[5] **Hoegh-Guldberg O, Jacob D, Taylor M, Bindi M, Brown S, Camilloni I, et al. Impacts of 1.5 C global warming on natural and human systems. Global warming of 1.5° C: an IPCC special report. IPCC Secretariat; 2018. p. 175–311 [This chapter is within the IPCC Special Report on 1.5 degree warming discussing impact on the natural and human systems including health].
[6] **Chan EYY, Shaw R. Public health and disasters: health emergency and disaster risk management in Asia. Singapore: Springer; 2020 [This is the first book discussing interlinkages and progress of Health-EDRM comprehensively].
[7] **Lo STT, Chan EYY, Chan GKW, Murray V, Abrahams J, Ardalan A, et al. Health emergency and disaster risk management (Health-EDRM): developing the research field within the Sendai framework paradigm. International Journal of Disaster Risk Science 2017;8(2):145–9 [This is another important paper discussing health and disasters written by the Health-EDRM science working group members].
[8] UNDRR. The 2019 Global Assessment Report (GAR); 2000 (300 p, Geneva).
[9] di Floristella AP. Dealing with natural disasters: risk society and ASEAN: a new approach to disaster management. The Pacific Review 2016;29(2):283–305.
[10] Petz D. Brookings-LSE Project on internal displacement, strengthening regional and national capacity for disaster risk management: the case of ASEAN; 2014.
[11] Murthy P. Relevance of SAARC. Strategic Analysis 2000;23(10):1781–96.
[12] Lamichhane S. Enhancing SAARC disaster management: a comparative study with ASEAN coordinating centre for humanitarian assistance on disaster management. Naval Postgraduate School Monterey United States; 2016.
[13] Hua J, Shaw R. Coronavirus (COVID-19) "infodemic" and emerging issues through a data lens: the case of China. International Journal of Environmental Research and Public Health 2020 [in press, under review].

[14] *Nature Journal Editorial. Coronavirus: three things all governments and their science advisers must do now. https://www.nature.com/articles/d41586-020-00772-4; 17 March 2020.
[15] Poljansek K, Marín Ferrer M, De Groeve T, Clark I. Science for disaster risk management 2017: knowing better and losing less. ETH Zurich; 2017.
[16] Banwell N, Rutherford S, Mackey B, Chu C. Towards improved linkage of disaster risk reduction and climate change adaptation in health: a review. Int J Environ Res Public Health 2018;15(4).
[17] Pescaroli G, Alexander D. Understanding compound, interconnected, interacting, and cascading risks: a holistic framework. Risk Anal 2018;38(11):2245–57.
[18] Boin A, McConnell A. Preparing for critical infrastructure breakdowns: the limits of crisis management and the need for resilience. Journal of contingencies and crisis management 2007;15(1):50–9.
[19] ***Garschagen M, Hagenlocher M, Comes M, Dubbert M, Sabelfeld R, Lee YJ, et al. World risk report 2016: critical infrastructure and resilience. UNU-EHS; 2016.
[20] Sterbenz JP, Hutchison D, Çetinkaya EK, Jabbar A, Rohrer JP, Schöller M, et al. Redundancy, diversity, and connectivity to achieve multilevel network resilience, survivability, and disruption tolerance invited paper. Telecommunication Systems 2014;56(1):17–31.
[21] Allen KM. Community-based disaster preparedness and climate adaptation: local capacity-building in the Philippines. Disasters 2006;30(1):81–101.
[22] *Shaw R, editor. Community based disaster risk reduction. Emerald Group Publishing; 2012.
[23] Scherer CW, Cho H. A social network contagion theory of risk perception. Risk Analysis: An International Journal 2003;23(2):261–7.
[24] Ho MC, Shaw D, Lin S, Chiu YC. How do disaster characteristics influence risk perception? Risk Analysis: An International Journal 2008;28(3):635–43.

Key organisations' websites

[1] ADB. COVID-19 (coronavirus): ADB'S response; 20 March 2020.
[2] AHA Center. About us; 20 March 2020.
[3] ASEAN. ASEAN health sector efforts in the prevention, detection and response to coronavirus disease 2019 (COVID-19); 20 March 2020.
[4] ASEAN. ASEAN | One vision one identity one community; 20 March 2020.
[5] EU. Coronavirus response; 20 March 2020.
[6] EU. European Union support to the Sendai Framework for Disaster Risk Reduction (2015–2030); 2015.
[7] EU. Sendai Framework for disaster risk reduction 2015–2030; 2015.
[8] EU. The EU integrated political crisis response – IPCR – arrangements; 2016.
[9] Government of Canada. Government of Canada takes action on COVID-19; 20 March 2020.
[10] Government of Indonesia. Covid19.go.id: Home; 20 March 2020.
[11] Government of Indonesia. Indonesia Sets Aside $70 Million to Fight Covid-19; 18 March 2020.
[12] Government of Japan. Information related to COVID-19. http://japan.kantei.go.jp/index.html; 20 March 2020.
[13] Government of the United Kingdom. Support for those affected by Covid-19; 19 March 2020.
[14] Government of the United States of America. Government Response to Coronavirus, COVID-19; 20 March 2020.
[15] **UN. Transforming our world: the 2030 agenda for sustainable development; 2015.
[16] **UN. The global goals; 20 March 2020.
[17] UN. UN releases emergency funds to help vulnerable countries fight COVID-19. https://news.un.org/en/story/2020/03/1058391?fbclid=IwAR3AmO9Jt_BYJxJ-FY_1kVH9jz7YW_5oOwibBTXpcM09wBPj1wz5cAht7N8; 1 March 2020.
[18] IFRC. COVID-19: IFRC, UNICEF and WHO issue guidance to protect children and support safe school operations; 12 March 2020.
[19] IMF. IMF makes available $50 billion to help address coronavirus; 10 March 2020.
[20] *UNDRR. UNDRR urges disaster management agencies to prioritize biological; 12 March 2020.
[21] **UNISDR. Sendai Framework for disaster risk reduction 2015–2030; 2015.
[22] WB. World Bank Group increases COVID-19 response to $14 billion to help sustain economies, protect jobs; 17 March 2020.
[23] WHO. Operational planning guidelines to support country preparedness and response; 19 March 2020.
[24] **WHO. Health emergency and disaster risk management framework pdf, 1.04Mb; 2019.
[25] WHO-A. Coronavirus (COVID-19) | WHO | Regional Office for Africa; 18 March 2020.
[26] WHO. COVID-19 response fund; 18 March 2020.
[27] Melinda and Gates Foundation. COVID-19; 12 March 2020.

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Building Holistic Resilience: Tokyo's 2050 Strategy

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Abstract: The paper examines Japan's capital city of Tokyo's "Zero Emission Tokyo Strategy." Our work shows that Tokyo's strategy is particularly important in light of the 2030 Agenda's emphasis on greenhouse-gas emissions reduction, equitable sustainability, and building holistic resilience against all hazards. The data indicate that Tokyo's ambitions are built on a track record of global leadership in resource efficient water systems, transit networks, and other critical infrastructure. Moreover, Tokyo is part of Japan's zero-emission communities, smart cities, all-hazard resilience, and other multilevel and silo-breaking collaborative platforms. Our analysis also makes recommendations for bolstering Tokyo's strategy, to enhance co-benefits from integrating climate change mitigation and adaptation, in addition to strengthening pandemic response.

Introduction

On December 27, 2019, Japan's capital city of Tokyo committed itself to a "Zero Emission Tokyo Strategy."[1] The strategy aims to achieve net zero greenhouse gas emissions by 2050. Like all other climate strategies, Tokyo's is a work in progress. It has yet to adequately detail co-benefits from integrating climate change mitigation and adaptation, notably in the area of human health. But Tokyo's example is important for a host of reasons. First, Tokyo is the world's largest megacity. What it does influences other Japanese municipalities and indeed other global cities. Second, Tokyo's strategy is multi-sectoral and pragmatic, rather than overly reliant on idealistic energy visions. Third, Tokyo is investing heavily in the people and critical infrastructure essential to realizing its ambitions. Its increasingly aggressive and smart fiscal policy affords a benchmark for an age of economic and ecosystem disruption coupled with accelerating technological innovation. As many unprepared cities and nations are discovering, well-targeted preparatory investment is particularly essential in the face of COVID-19 and future pandemics. Fourth, Tokyo emphasizes integrated and inclusive governance, which enhances the prospects for implementation and continued policy evolution. Fifth, studying Tokyo's strategy opens windows on the platform collaborations that Japanese "silo-breakers"[2] have been building since 3-11, to maximize holistic resilience. In this paper, we review the evidence and make three key points. We argue that Tokyo's ambition is credible, in large part because it already deploys resilient and decarbonizing critical infrastructure networks that simultaneously mitigate and adapt to climate change, resource crises, and other challenges. We also argue that Tokyo's integrated and well-funded strategy offers a model, not just for melding the Paris Agreement, Sustainable Development Goals (SDGs), and the Sendai Framework for Disaster Risk Reduction, but also keeping them on track in the face of unprecedented uncertainty. And in our conclusions, we urge Tokyo to adopt several recommendations to bolster its strategy in light of emerging needs and opportunities.

Tokyo's 2050 strategy

Key to Tokyo's zero emission strategy (hereafter "TMG 2050") is integration. TMG 2050 builds on an institutional legacy of metropolitan governance and a multiplicity of past and present initiatives in energy, disaster risk reduction, waste, transport, and other areas. Tokyo Metropolitan Government's (TMG) transport, sewerage, and other planning successes have made it one of the world's most energy- and material-efficient city-regions. What is new is TMG 2050's integration of climate mitigation and adaptation towards achieving zero emissions. TMG 2050 thus differs from previous sector-specific environmental initiatives. It puts cross-sectoral initiatives at the heart of comprehensive city planning by focusing planning, finance, and collaboration on zero emissions.

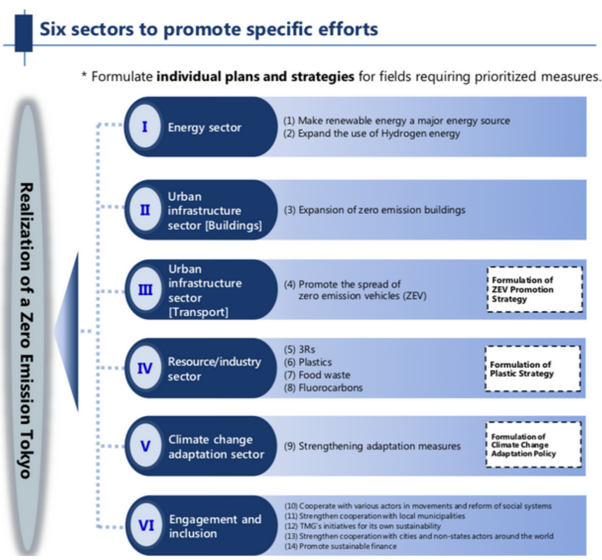

Figure 1: TMG 2050 and Tokyo Metropolitan Government (Click to enlarge)

Figure 1 shows that TMG 2050 also melds the "hard" infrastructure of technology with the "soft" infrastructure of inclusive governance. The figure outlines the six main sectors involved in reducing emissions towards the 2050 target. The first sector is energy (electricity and heat), globally responsible for just under a third of greenhouse gas GHG emissions. Yet note that TMG 2050 does not rely on glib promises of achieving 100% renewable energy in power and heat in a decade or even by 2050. Such bold pledges are common, according to the American Council for an Energy-Efficient Economy, but generally not monitored for progress or actual GHG reductions.[3] Incredibly, even Boston, the top-ranked US zero-emission city, does not have a "quantitative municipal energy goal."[4] And the city of Berlin, the heart of Germany's "energy transition," is ostensibly committed to 100% renewables by 2050, but is evidently doing little to get there. The most current data from the German Federal Renewable Energies Agency show that by 2016 Berlin had achieved only 4% renewables in primary energy (2.5% in gross electricity consumption), only a marginal increase from 3.7% in 2013. And Berlin's per-capita CO_2 (not GHG emissions in total) emissions had only declined from 5.3 tonnes in 2013 to 4.7 tonnes in 2016.[5]

It therefore seems commendable that TMG 2050 does not rely on 100% renewables to achieve decarbonization commitments, but instead aims at achievable, cross-sectoral goals that link technology and inclusive governance. The figure shows that TMG 2050 positions renewable energy as a "major energy source" rather than the only source. In fact, the details of TMG's energy planning show that reliance on renewable energy is to be roughly doubled, from 14.1% in 2017 to 30% by 2050.[6]

Simultaneously, looking at the second and third sectors outlined in figure 1, TMG 2050 plans a drastic cut in emissions from the building and transport sectors. These sectors are major sources of GHG emissions, not just through consumption of liquid fuels but also the use of power for lighting, thermal comfort, and other building operations. TMG 2050's aims in these two sectors are a significant acceleration of the

GHG reductions it has already achieved since 2015, which marks TMG's post-Fukushima peak of GHG emissions.[7] In other words, TMG's ratcheting-up of ambitions credibly builds on demonstrated prior performance.

In the resource/industry sector, 4th in figure 1, TMG aims to ramp up its already aggressive policies of reduce, reuse and recycle (3Rs), particularly in plastics, food waste and fluorocarbons. These latter two – food waste and fluorocarbons – are especially important for any viable strategy of drawing down GHG emissions.[8]

The fifth sector in the figure is "climate change adaptation." TMG 2050 positions adaptation as an explicit part of achieving zero emissions. Indeed, green infrastructure and myriad other adaptation initiatives also enhance mitigation, thereby multiplying co-benefits, reducing per-unit costs, and maximizing societal agreement on action.[9]

Finally, figure 1's sixth sector of "engagement and inclusion" outlines a programme of working with civil society, other levels of government, and international subnational governments and non-state actors. This institutional and societal collaboration is embedded in TMG's role as a metropolitan government, integrating 23 special wards and 39 municipalities. It is also evident in the multiple collaborative platforms – SDG cities, smart cities, national resilience – we describe later below.

TMG 2050 and Tokyo Resource-Efficiency

We suggested earlier that TMG 2050 is not mere virtue-signaling, but rather builds on TMG's strengths. A few examples shall suffice. TMG's per-capita energy, water and waste flows are considerable below the average of such peers as Shanghai, New York City, London, Paris, and others.[10] TMG also installed Japan – and the world's – first urban cap and trade scheme that includes the commercial and industrial sector, "including office buildings, which are often concentrated in megacities."[11] TMG and other large Japanese cities – notable Fukuoka – are generally built in a compact manner that fosters efficient resource use and limits urban sprawl.

The importance of TMG-style resource-efficiency is seen in the UNEP's International Resource Panel (IRP) 2018 report on "The Weight of Cities: Resource Requirements of Future Urbanization." The IRP calculate the historic trajectory for urban sprawl to be about 2%/yr, a pace that – if continued - would see urban land use expand from 1 million km2 at present to 2.5 million sq2 by 2050. That extra 1.5 million sq2 of urban space would be approximately 3 times the 506,000 km2 area of the entire country of Spain. In tandem with that, urban material consumption is on track to grow from 40 billion tonnes in 2010 to 90 billion tonnes by 2050.

Those numbers are daunting. But the IRP argue that "compact, resource-efficient cities" could reduce these totals by 36-45%. As a benchmark for better performance, the IRP report notes that "Japanese cities have the densest and most connected street patterns," with Tokyo's "level of transit connectivity and intensity of use" being the highest in the world. These structural factors give Japan "the highest world energy productivity (ratio of energy consumption to added value), close to three times the global average."[12] Zooming in on TMG, we see one clear example of this resource-efficiency. The Tokyo Metro transit network's 382 kilometers of track is far less than Shanghai's 639 kilometers, and even New York's 401 kilometers; but in 2018 its annual ridership of 3.463 billion was the world's largest, dwarfing that of second-ranked Moscow (2.369 billion), 3rd-ranked Shanghai (2.044 billion), and 6th-ranked New York City (1.806 billion).[13]

TMG's water supply is another area of demonstrated resilience and resource-efficiency. As in any city, TMG's water-related systems (e.g., sewerages) are energy-intensive and crucial to public health. Moving around huge volumes of water (for TMG, a daily average of 4.13 million cubic liters in 2018), whether for consumption or for waste-treatment, requires prodigious amounts of energy. And poorly designed or badly managed water systems pose enormous health and disaster risks, in addition to wasting precious resources.[14] TMG's replacement of its leaky lead and iron pipe network with stainless steel brought its water loss down from 17% in the 1970s to an incredibly low 2% in the 2010s. At present, TMG's rate of water loss is well under the double-digit leakage rates that OECD reports on "Water and Cities" indicate are common even in developed countries.[15] TMG's capacity to plan and operate its water networks on a metropolitan scale - coupled with institutionalized consultation with its special wards and cities - allows expert information and other scarce resources to be focused on the macro-level management challenge. Rather than leaving each local actor to – as it were – reinvent the wheel on its own, strong metropolitan governance affords the capacity to devise and deploy best-practice solutions.

The importance of collaborative governance needs to be underscored in light of global sustainability challenges. Experts on urban systems argue for a 'one-water approach.' Key to this approach is integration of governance and technology, as it "seeks to integrate various water supply, treatment and management infrastructures into a single infrastructure system perspective that considers the full life cycle of water provisioning in urban areas, [that] can simultaneously deliver livability, resilience and sustainability benefits."[16] TMG does this with its water networks and other critical infrastructure, scaling up the "system of systems" cross-sector integration that is core to TMG 2050.

TMG 2050 and Public Finance

TMG also puts its money where its mouth is, so to speak. Its commitment to TMG 2050 is seen in the scale and focus of its multi-year funds and annual budgets. As to the former, since FY 2017 TMG has adopted a triad approach to rolling out modernized urban amenities: "safety city," "smart city," and "diver-city" (the latter a combination, in Japanese script, of "diverse" and "city"). To support these initiatives, TMG amalgamated its multi-trillion yen funds,[17] under these three rubrics of safe, smart and diverse. Well before the unfolding global pandemic, TMG had targeted roughly JPY 1 trillion in spending on these initiatives, outside of the annual budgets, between 2017 and 2020.

In 2019, TMG further sharpened the focus on categories critical to TMG 2050. It created three new special purpose funds in 2019, totaling JPY 110 billion. Of this total, JPY 50 billion is devoted to realizing a Society 5.0-type[18] smart city, JPY 30 billion to zero emissions projects such as fuel-cell vehicles, and JPY 30 billion to greening of TMG. Moreover, these new financing vehicles bring the cumulative total (at end of FY 2020) of the relevant funds to JPY 1.77 trillion. Of this JPY 1.77 trillion total, fully JPY 733.2 billion is to be spent within FY 2020 alone for modernized critical infrastructure (waterworks, transport, communications, medical, and other areas), disaster resilience, pandemic response, and other public goods. These investment areas are all pertinent to achieving TMG 2050's cross-sectoral goals.[19]

The annual spending in TMG's general account is JPY 7.3 trillion. As in previous years, spending from the FY 2020 general account also features the triad of "safety city," "smart city," and "diver-city." But in comparison to previous years, the FY 2020 investments show dramatic increases.[20] The summary details are as follows:

1. The safety-city budget overall is JPY 328 billion (versus JPY 300 billion in FY 2019) centred on disaster-resilient water networks and bolstering structures against seismic threats and risks of cascading fires.

2. The smart city component of the FY 2020 budget totals JPY 654.8 billion, double the JPY 326 billion total in 2019. Much of this spending focuses on building up transport efficiency by integrating tele-work, transit-demand management and other smart initiatives. The most striking aspect is the 8-fold increase over the previous year in spending on 5G wireless transmission and other core technologies of a "Smart Tokyo."

3. The diversity-city aspect totals JPY 550.5 billion, a dramatic increase from 353 billion in 2019. Significant investments are focused on foreigners, the disabled, and other potentially vulnerable members of the community. And fully JPY 174 billion is devoted to augmenting the national government's initiatives providing free child-care and kindergarten education. To some observers, these items may seem extraneous to climate objectives. But relieving child poverty, increasing women's opportunities, enhancing work-life balance are in fact crucial elements of emissions reduction and sustainability.[21]

TMG has also been quick to fill in safety-city gaps in pandemic response. As the COVID-19 pandemic threat emerged and then worsened from January of 2020, TMG responded rapidly with supplementary budgets. On February 18 of 2020, TMG announced that an initial JPY 6.4 billion in countermeasures, added to the FY 2019 budget, would be more than quintupled to JPY 33.7 billion as a special addition to FY 2020. Both of these spending packages are directed at a spate of measures, including tests and other supplies in addition to alleviating the economic impact on small firms. Comparing these two supplementary spending measures, we see that the largest increase is the JPY 10 million to JPY 2.6 billion rise for stockpiling medical supplies, readying medical facilities, and other measures.[22]

In summary, TMG's investments belie the hoary depiction of Japanese public works as "bridges to nowhere." They also provide an important model. In the face of COVID-19, most countries have moved rapidly towards very activist fiscal policy. As of this writing, the G-20 total for fiscal countermeasures is USD 5 trillion, which is roughly the size of the Japanese economy.[23] In many countries, the initial focus on supporting businesses and households in the face of simultaneous supply and demand shocks will almost inevitably move to infrastructure investment. For example, analysts indicate that the broad range of categories encompassed by smart cities are likely to become an even strong focus of public and private investment.[24] TMG's fiscal data suggest that it already offers multiple yardsticks of how to invest so as to achieve multiple decarbonizing co-benefits simultaneously.

TMG 2050 and Other Japanese Cases

In pursuing zero-emissions, TMG is not alone among Japanese subnational governments. Indeed, one prominent area of collaboration in Japan is its national alliance for 2050 zero carbon cities (with the Ministry of the Environment, but as part of larger horizontal/vertical collaboration). As of March 24, 2020, 86 of Japan's subnational governments – representing 48.5% of the country's population – had adopted the strategy. Figure 2 displays most of the 26 prefectures (of Japan's total 47 prefectures) that have adopted the strategy, and also shows that many large and small cities are acting independently of their prefecture. One example is the city of Koriyama's commitment to the strategy, in advance of any announcement by the prefecture of Fukushima. At nearly the opposite end of the archipelago, the prefecture of Kumamoto has essentially organized 18 of its 45 municipalities into a coordinated bloc.

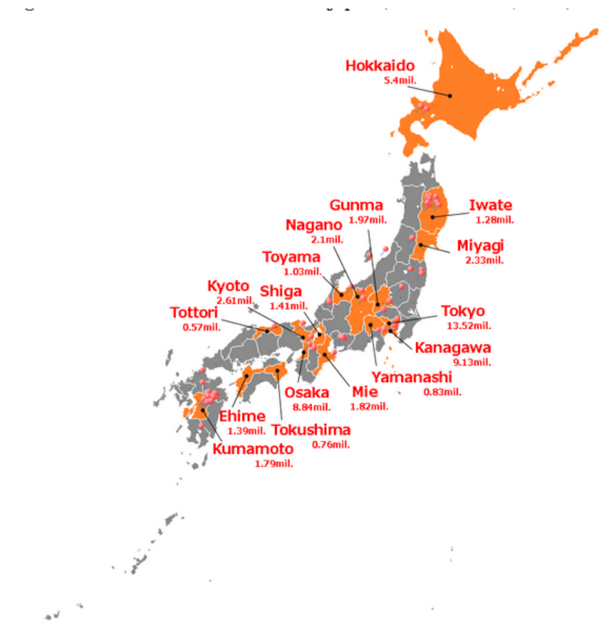

Figure 2: 2050 Zero Carbon Cities in Japan (as of March 24, 2020) Source: MoE, 2020[25]

Within this nexus of collaboration, increasingly ambitious but doable targets are emerging. For example, on December 25 of 2019, Gunma Prefecture announced a 5-zero by 2050 programme.[26] The goals include the following:

1. zero deaths due to disasters
2. zero emissions, especially through hydro and forest biomass
3. zero blackouts due to disasters, via use of microgrids and other smart infrastructure
4. zero plastic waste, through recycling and reduction of use
5. zero food loss, particularly by repurposing food that currently goes into the waste stream

Like TMG 2050, Gunma's goals build on multilevel collaborations detailed below, including SDGs, smart city, and national resilience.

Other Multilevel Collaborations in Japan

TMG has been a global first-mover on implementing the UN's Sustainable Development Goals (SDGs), a major part of the 2030 Agenda.[27] But so has the national government, via the cabinet office and other agencies. Developed countries tend to view the SDGs as a template to guide assistance to developing countries. However, Japan's Cabinet Office has quite deliberately[28] built a platform for subnational (prefectural and municipal) models of "local revitalization" SDGs.[29] Since 2017, the multi-level collaboration has been using the 17 goals and 169 targets of the SDGs as means to focus Japanese initiatives to cope with myriad domestic challenges while simultaneously enhancing opportunities for overseas engagement and contributions. Within the Cabinet Office's facility, Japan's subnational governments compete to be one of the 100 designated SDG initiatives. The Japanese platform distills the multiplicity of SDG goals into 8 areas: inclusiveness and gender-equality, health and longevity, economic growth with innovation, sustainable and resilient critical infrastructure, resilient and decarbonizing energy, biodiversity and ecosystem conservation, global peace and security, and global engagement for promoting the SDGs. In tandem, the national government has linked its Society 5.0 industrial policy and related initiatives to the SDGs as a means of fostering silo-breaking policy coherence in tandem with expanded global collaboration.[30]

A related multi-level platform approach applies to Japan's smart city collaboration. Since its creation in 2019, Japan's Smart City platform has grown to 570 members and 170 industrial policy initiatives. The members are composed of 113 local governments, 356 firms and research institutes (including universities), 11 central agencies, and 2 economic associations. Like the SDGs platform, the Smart City platform is a locus for integrating governance and technology, a venue for facilitating collaborative learning and diffusion of best-practice solutions to domestic and global challenges. TMG's projects are prominent in the platform, and are thus well-positioned as models for other local governments.[31]

Perhaps most importantly, the national government, TMG and other subnational governments are also closely linked in an expanding portfolio of national and subnational "National Resilience Plans" (NRPs) that have legal precedence over other plans.[32] This platform has several years of institutionalization. Japan's NRP is based on the National Resilience Law passed by the Diet on December 4 of 2013.[33] The NRP is comprehensive, inclusive and transparent. It is aimed at bolstering the country's resilience to natural disasters and other hazards, as well as fostering the capacity to recover from such disasters when they occur. It is also explicitly addressed to demographic and other challenges. Based on national and international evidence, it evaluates risks and vulnerabilities, selects and prioritizes countermeasures, and then monitors progress on these measures. As shown in figure 3, the NRP are umbrella plans: as of 2019, 46 other national plans refer to the NRP. These plans include energy, environmental, city-planning, ageing society, forestry, space, and other plans. An additional 18 plans are slated to be added to the list, including the Comprehensive Innovation Strategy, the Global Warming Counter-Measures Plan, and the Basic Plan on Ocean Policy.[34] The broad reach of the NRP allows it to address disaster, demographic and other hazards. Comprehensive and integrated planning also allows the NRP cycle to emphasize cost-effective, cross-sectoral adaptation to multiple risks while also achieving broader socio-economic sustainability and decarbonization.

Figure 3: Planning and Japan National Resilience
Source: Japanese Cabinet Office (Click to expand)

As figure 4 indicates, the NRP is also a "whole of government" approach to planning. In 2014, the NRP was worked up into a plan by the governing LDP politicians and disaster-resilience technocrats in the Cabinet Secretariat's National Resilience Promotion

Office (NRPO). It was also studied by the National Resilience (Disaster Prevention and Reduction) Deliberation Committee (NRDC). The NRDC first met on March 5, 2013 and had its 53rd meeting on March 23, 2020. It has played a prominent role in overseeing 2 iterations (2014, 2018) of the NRP Basic Plan as well as 6 annual action plans that decide and then monitor the PDCA planning cycle and the achievement of Key Performance Indicators (KPI). These KPIs include hard measures, such as reinforcing water-treatment systems, and soft measures, such as skill-building and means to break down governance silos. In the 2019 revision of the original 5-year NRP basic plan, the number of KPIs had increased to 179. These KPIs cover a very broad range of hard and soft measures to secure holistic and inclusive resilience.

The NRDC's membership is drawn primarily from the top ranks of Japanese academe, business, and subnational government. Its specialists advise on ageing, primary industries, local communities, local administration, risk communication, industrial structure, the environment, disaster prevention, finance, national lands, and information services. These people and institutions are silo-breakers, in that their collaboration brings together often balkanized sectors. Their silo-breaking role is clear from studying the plans they have built and continue to refine. Indeed, in a laudable exercise in transparency, the minutes from NRDC meetings and the materials it deliberates are uploaded to its dedicated web site, generally within a week of its 7-9 meetings each year.[35]

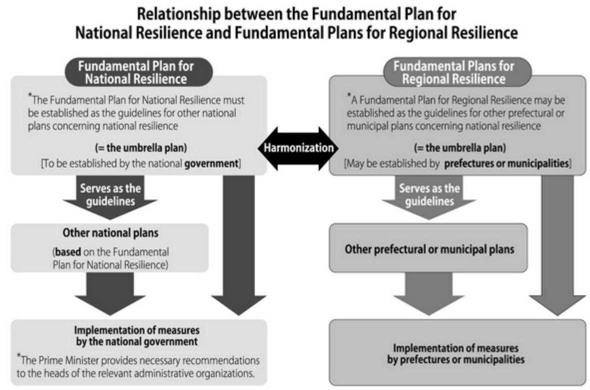

Figure 4: Whole of Government and National Resilience
Source: Japanese Cabinet Office (Click to expand)

A key test of any such ostensibly collaborative initiative is how well it diffuses and how purposefully engaged the actors are. By that measure, national resilience is even more successful than the SDGs and Smart City platforms described earlier. By March 1 of 2020, all of Japan's 47 prefectures had adopted their own regional versions of the NRP. Moreover, 1,355 of Japan's 1741 cities and towns had either adopted their own local versions of the NRP or were formulating plans. This number of cities, towns and villages doing NRPs was more than a quintupling of the 196 total from June of 2019.[36] That startling rate of increase, in well under a year, was testament to the rapid spread of risk-awareness in Japan. Recent years of repeated typhoons, floods and other disasters have led to a consensus on the need for comprehensive planning and integrated counter-measures.

As to subnational engagement, that is evident in the content of their planning and implementation. All the prefectural and local plans are formulated on the basis of local risk assessments, built on the advice of local experts, open meetings, and responsiveness to public comments on planning proposals. In other words, the local plans are not "cookiecutter" versions of the national plan, mere passive compliance with central-government directives in order to maximize public works. Japanese resilience is certainly well-funded, at roughly JPY 5 trillion per year. But the investments finance soft and hard measures in addition to training and international engagement. The national and subnational plans, budgets, committee representation, and other aspects are all open to inspection and input from civil society. Spending categories and performance indicators are presented in graphic and tabular formats.[37]

In addition to the above platforms on SDG cities, smart cities, and resilience, we could have outlined Japan's platforms for compact cities, green infrastructure, and other elements of holistic resilience. But we think the examples suffice to show that TMG's policymakers work in a variety of multilevel collaborations. Most of these platforms include all levels of government and reach deeply into civil society.

TMG's Broader Significance

Japan seeks to export its collaborative, resilient and resource-efficient urbanization. One indicator of this is seen in Japan's cooperation with the World Bank on disaster-resilient urban "lifeline" infrastructure. The World Bank has long argued that compact design affords more green space, enhances the efficiency of material use, and reduces disaster and other risks. In June of 2019, the World Bank quantified the benefit of this kind of urbanization, in low and middle-income countries, as potentially USD 4.2 trillion in avoided costs from damage and disruptions. The ratio of initial investment cost versus avoided costs was calculated at 1:4, meaning investment in resilient infrastructure more than paid for itself over the lifecycle.[38]

Japan's active collaboration with the World Bank came in tandem with its securing G20 agreement, in June of 2019, to Principles for Quality Infrastructure Investment that include comprehensive quantification of lifecycle costs. These principles are non-binding but meld environmental, societal, fiscal and other modes of sustainability. Close observers of G20 processes regard them as one of the key developments in 2019.[39] Indeed, it is difficult to exaggerate the significance of bringing the 2030 Agenda into the highest levels of decision making on global infrastructure, which is routinely assessed to represent a cumulative USD 80 trillion in investment by 2040.

One example of the prodigious body of research highlighting the importance of resilient infrastructure is the October, 2018 collaboration between Oxford University and the United Nations Office for Project Services, in their report "Infrastructure Underpinning Sustainable Development."[40] They place infrastructure investments in a broader mix of critical public goods. These latter include investments in health, education and food security, underpinned by sustainable management of water resources. Like TMG 2050, these integrated initiatives offer no-regret pragmatism: in the face of climate, geopolitical and business uncertainty, there can be no doubt that providing children with clean water and other public goods will improve their health and alleviate pandemic risks.

Further Integrated Resilience and the TMG Paradigm

We have seen that TMG 2050 is part of a larger paradigm of platforms. Japan offers lessons in governance and the integration of technology, to help cope with multiple challenges simultaneously. Climate change is a wicked problem and very likely an existential crisis. Assessing and addressing climate change is always fraught with disagreements and distractions, because short-term thinking is so greatly advantaged over long-term planning.

The unfolding pandemic and economic crisis seem likely to worsen that structural problem by impeding “super year” 2020’s multiple important negotiations over biodiversity, the oceans, and COP 26.[41] But Japan’s example suggests powerful coalitions can be built by including a variety of no-regret “solutions” framed in terms of the 2030 Agenda.

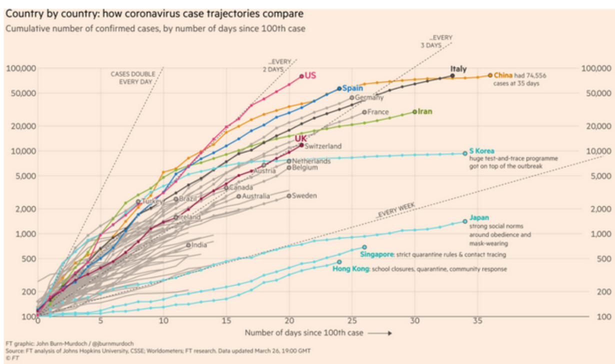

Figure 5: Global Spread of Coronavirus (as of March 26, 2020)
Source: *Financial Times*, March 26, 2020
(Click to expand)

Yet in light of COVID-19, it is imperative that there be tighter integration of pandemic risk-reduction and response in TMG 2050 and other multilevel collaboration. Though Japan’s response to COVID-19 has generally been derided in international and domestic media reports, the country appears – as of this writing – to have minimized COVID-19’s spread. This result is unexpected, particularly because Japan’s aging, population density and other important variables exceed those of heavily impacted Italy. Figure 5 shows that after the 10th recorded death from the coronavirus, Japan seems to have nearly flattened the upward curve of infection. The figure suggests that South Korea is leading in flattening the curve, with Japan, Hong Kong and Singapore not far behind. Japan may be in a much better position than most of Europe and North America, not to mention Brazil, India, Indonesia and other populous countries. The US appears to be in particularly dire straits, which is especially surprising in light of its 2019 ranking as the world’s most advanced case of health security.[42]

Whether Japan’s current comparatively low levels of COVID-19 infection, hospitalization, and mortality are due to good policy, good luck or simply poor data cannot yet be conclusively determined. In any event, there are many areas for improvement. On this, Japan’s 26 national resilience working groups include a high-level “STOP Pandemics 2020 Strategy Committee.”[43] The Committee is chaired by highly respected Professor Kaku Mitsuo of Tohoku Medical and Pharmaceutical University and lead author of the February 25, 2020 “Citizen’s Handbook” on avoiding COVID-19 infection.[44] In a February 10, 2020 forum, the working group made a number of recommendations concerning better integration of pandemic risks into all-hazard National Resilience. It also made recommendations on risk-communication, preparedness, and related items.[45] It is slated to provide further recommendations in April, with presumably more specific protocols in addition to how to better integrate pandemic risk-reduction into Japan’s resilience paradigm.

But requisite reforms go beyond Japan’s domestic protocols, platforms and paradigms. We have argued elsewhere[46] that the pandemic response could be bolstered by greater use of the WHO framework on health-emergency disaster-risk management (Health-EDRM). The WHO describes Health-EDRM as the “systematic analysis and management of health risks, posed by emergencies and disasters, through a combination of (1) hazard and vulnerability reduction to prevent and mitigate risks, (2) preparedness, (3) response and (4) recovery measures.”[47] WHO’s current technical guidance has not incorporated the Health-EDRM.

Also, one would have expected the pandemic to have galvanized the international disaster-risk reduction (DRR) community. Certainly the UN Office for Disaster Risk Reduction (UNDRR) issued a March 12 press release exhorting disaster management agencies to "prioritize biological hazards." The UNDRR duly observes that natural hazards are the focus for national disaster management agencies. It encourages them to include health emergencies as a top priority, because they clearly lead to cascading systemic breakdown in such critical infrastructure as health care and financial services. Yet we are now 5 years out from 2015 adoption of the Sendai Framework on Disaster Risk Reduction, in tandem with the Paris Agreement and the SDGs. Sendai explicitly incorporates climate change, health risks, and the urgency of acting in advance rather than waiting and then responding. Surely the present crisis should produce a more substantive response, particularly in such an important year for further institutionalizing and integrating the 2030 Agenda.

We argued that TMG's example, and its TMG 2050, suggests that robust and integrated governance can help cities maximize mitigation and adaptation. TMG 2050 deserves close attention because it is a very democratic, collaborative benchmark built on impressive results, smart industrial policy, aggressive fiscal policy, and an emphasis on equity and inclusivity. We also pointed out that TMG 2050 is not acting on its own, but rather in an "all of government" array of platforms and through international engagement. Japanese silo-breaking is leading to substantial progress in integrating the three key elements - Paris, SDGs, and Sendai – of the 2030 Agenda. We can only hope Japan contributes to keeping the 2030 Agenda on track in this potentially distracting, disruptive and divisive year.

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Notes

[1] Tokyo's Zero Emission Strategy is available at the following URL:
https://www.kankyo.metro.tokyo.lg.jp/en/about_us/zero_emission_tokyo/strategy.html

[2] Silo-breakers are individuals and institutions that break down the walls – or "silos"- that separate public-sector governance, business management, and other areas. For their role in disaster risk reduction and climate adaptation, see "Silo-breakers: Asia and the Pacific calls for integrating climate adaptation and disaster risk reduction," United Nations Office of Disaster Risk Reduction, September 6, 2019:
https://www.undrr.org/news/silo-breakers-asia-and-pacific-calls-integrating-climate-adaptation

-and-disaster-risk
[3] On this lack of monitoring, see "US Cities Boost Clean Energy Efforts, but Few on Track to Meet climate Goals," American Council for an Energy-Efficient Economy, July 24, 2019: https://www.aceee.org/press/2019/07/us-cities-boost-clean-energy-efforts-0
[4] See the US city database and assessments at "State and Local Policy Database," American Council for an Energy-Efficient Economy, March, 2020: https://database.aceee.org/city-scorecard-rank
[5] The Berlin City data are available (in German) at "Berlin (B)," German Federal Renewable Energies Agency: https://www.foederal-erneuerbar.de/landesinfo/bundesland/B/kategorie/top%2010/auswahl/289-anteil_erneuerbarer_/#goto_289
[6] Tokyo's 2017 level of 14.1% renewable energy is displayed (in Japanese) on p. 124 of the Tokyo Environmental White Paper, 2019: https://www.kankyo.metro.tokyo.lg.jp/basic/plan/white_paper/100200a20191031132600879.files/2019zenbun.pdf
[7] Tokyo's GHG emissions data can be referenced (in Japanese) on p. 125 of the Tokyo Environmental White Paper, 2019: https://www.kankyo.metro.tokyo.lg.jp/basic/plan/white_paper/100200a20191031132600879.files/2019zenbun.pdf
[8] On this point, note that "Project Drawdown" has assessed refrigerant management/alternative refrigerants and reduced food waste as among the top actions in effective GHG emissions reduction potential. See their comparative table on the scale of potential cuts: https://drawdown.org/solutions/table-of-solutions
[9] On green infrastructure in Japan, see Andrew DeWit "Is Japan a Climate Leader? Synergistic Integration of the 2030 Agenda," Japan Focus, February 1, 2020: https://apjjf.org/2020/3/DeWit.html
[10] These results were reported by what appears to be the first ever comparison of energy and other resource flows in megacities. See Kennedy, C. et al "Energy and material flows of megacities," Proc Natl Acad Sci U S A. 2015 May 12: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4434724/
[11] See "Creating a Sustainable City: Tokyo's Environmental Policy," Tokyo Metropolitan Government, September 2018: http://www.kankyo.metro.tokyo.jp/en/about_us/videos_documents/documents_1.files/creating_a_sustainable_city_2018_e.pdf
[12] See p. 109 "The Weight of Cities: Resource Requirements of Future Urbanization," International Resource Panel, 2018, available at the following URL: http://www.resourcepanel.org/reports/weight-cities
[13] The data are compiled by the International Association of Public Transport, and published as "World Metro Figures 2018": https://www.uitp.org/sites/default/files/cck-focus-papers-files/Statistics%20Brief%20-%20World%20metro%20figures%202018V4_WEB.pdf
[14] For example, Project Drawdown assess "water distribution efficiency" as representing an opportunity to halve water loss (currently 30.3 billion cubic liters/yr), reduce GHG emissions by, and save between USD 250-350 billion:

https://drawdown.org/solutions/water-distribution-efficiency
[15] On these items, see the OECD's work on Water and Cities: Ensuring Sustainable Futures: http://www.oecd.org/water/water-and-cities.htm
[16] See p. 109 "The Weight of Cities: Resource Requirements of Future Urbanization," International Resource Panel, 2018, available at the following URL: http://www.resourcepanel.org/reports/weight-cities
[17] These kinds of funds (*kikin*) are not peculiar to TMG, and are financed via such measures as accumulated savings from cost-cutting, unanticipated tax and related revenue increases, debt finance, and other items. Japanese subnational governments use these funds to smooth out annual budgeting as well as target special purposes (notably building municipal structures, supporting primary industries, and coping with aging). On these funds, and their striking increase in recent years, see (in Japanese) Tatsuoka Kenjiro, "Why Have Local Government Funds Increased?" JRI Review, 5(66), 2019: https://www.jri.co.jp/MediaLibrary/file/report/jrireview/pdf/11084.pdf
[18] On Japanese Society 5.0's integration of cyberspace and physical space, see "Society 5.0," Japanese Cabinet Office, nd: https://www8.cao.go.jp/cstp/english/society5_0/index.html
[19] See (in Japanese) p. 20-21 of "Tokyo Metropolitan Government Budget Summary, FY 2020," Tokyo Metropolitan Government, February: https://www.zaimu.metro.tokyo.lg.jp/syukei1/zaisei/20200124_reiwa2nendo_tokyotoyosanangaiyou/2yosanangaiyou.pdf
[20] Concerning TMG's FY 2019 and FY 2020 budgets, see (in Japanese) summaries at Tokyo Metropolitan Government finance website: https://www.zaimu.metro.tokyo.lg.jp/zaisei/
[21] Within an already voluminous literature on these matters, see "Christina Kwauk et al., "Girls' education in climate strategies," Brookings Working Paper, December 10, 2019: https://www.brookings.edu/research/girls-education-in-climate-strategies/
[22] The supplementary budgets are outlined (in Japanese) in detail "Concerning additions to the FY 2019 and FY 2020 supplementary budgets," Tokyo Metropolitan Government News, February 18, 2020: https://www.zaimu.metro.tokyo.lg.jp/yosan/20200218_hoseiyosanan_tsuika.pdf
[23] See "G-20 Nations Pledge $5 Trillion to Spur Global Economic Recovery From Coronavirus," Wall Street Journal, March 26, 2020.
[24] One recent assessment of the pandemic's implications for the smart city is seen in "Taking Stock of COVID-19: The Short- and Long-Term Ramifications on Technology and End Markets," ABI Research White Paper, March 18, 2020: https://www.abiresearch.com/press/covid-19-pandemic-will-force-companies-around-world-radically-rethink-how-they-operate-and-embrace-technological-investment/
[25] The Ministry of Environment "Zero Carbon Cities in Japan" mapping is available in English and regularly updated: http://www.env.go.jp/en/earth/cc/2050_zero_carbon_cities_in_japan.html
[26] The details of Gunma Prefecture's programme are available (in Japanese) at "Gunma Prefecture announces a 5-zeros by 2050 plan," Gunma Prefecture, December 25, 2019: https://www.pref.gunma.jp/04/e01g_00147.html
[27] The use of the term "2030 Agenda" derives from the fact that the UN's three landmark agreements – the SDGs, the Paris Agreement and the Sendai Framework on Disaster Risk

Reduction - all cover the 2015-2030 period. On the effort to enhance synergies among the three agreements, see Handmer, et al. "Achieving risk reduction across Sendai, Paris and the SDGs: International Science Council Policy Brief, May, 2019: https://council.science/wp-content/uploads/2019/05/ISC_Achieving-Risk-Reduction-Across-Sendai-Paris-and-the-SDGs_May-2019.pdf

[28] On the Japanese Cabinet Office's strategic approach to using the SDGs, see (in Japanese) Seki Sachiko "Concerning the Promotion of Japanese-Style SDGs," Governance, October, 2019.

[29] The platform is described (in Japanese) at: http://future-city.jp/sdgs/

[30] The categories are described in detail (in Japanese) at "SDGs Action Plan 2020," Cabinet Office, Government of Japan, December 2019: https://www.kantei.go.jp/jp/singi/sdgs/dai8/actionplan2020.pdf

[31] The Smart City platform's website (in Japanese) is here: https://www.mlit.go.jp/scpf/index.html

[32] The central government's National Resilience plans for 2014-2019 are available (in Japanese) here: https://www.cas.go.jp/jp/seisaku/kokudo_kyoujinka/kihon.html

[33] The National Resilience Plan and related materials are available (in Japanese) at the following internet URL: http://www.cas.go.jp/jp/seisaku/kokudo_kyoujinka/

[34] The list of plans is available (in Japanese) at "Concerning other national plans in regard to national resilience," Cabinet Office, March 25, 2019: https://www.cas.go.jp/jp/seisaku/resilience/dai47/siryo3-3.pdf

[35] The membership, minutes and materials studied by the National Resilience (Disaster Prevention and Reduction) Deliberation Committee are available (in Japanese) at the following internet URL: http://www.cas.go.jp/jp/seisaku/resilience/

[36] Links to Japan's subnational National Resilience plans are available (in Japanese) here: https://www.cas.go.jp/jp/seisaku/kokudo_kyoujinka/tiiki.html

[37] The plans, budgets, committee data, and other relevant information are available via the Cabinet Secretariat's dedicated website: https://www.cas.go.jp/jp/seisaku/kokudo_kyoujinka/

[38] On this, see "Lifelines: The Resilient Infrastructure Opportunity," World Bank, June 17, 2019: https://www.worldbank.org/en/news/infographic/2019/06/17/lifelines-the-resilient-infrastructure-opportunity

[39] One example is Center for Strategic and International Studies Senior Vice-President Matthew P. Goodman in his "Parsing the Osaka G20 Communique," Center for Strategic and International Studies, July 3, 2019: https://www.csis.org/analysis/parsing-osaka-g20-communiqué

[40] The report can be accessed at the following URL: https://www.itrc.org.uk/infrastructure-underpinning-sustainable-development/

[41] On this, see Fermin Koop, "Coronavirus hits crucial year for nature and climate," China Dialogue, March 19, 2020: https://www.chinadialogue.net/article/show/single/en/11915-Coronavirus-hits-crucial-year-for-nature-and-climate

[42] See the first-ever "Global Health Security Index," developed by the Economist, the Nuclear Threat Initiative, and the Johns Hopkins Center for Health Security. The Index is the world's

first, and in addition to getting the US wrong, lists Japan as 21st and Singapore as 24th. The Index is a very important initiative, but clearly needs silo-breaking revision of underlying assumptions and other factors. The Index is available at: https://www.ghsindex.org/wp-content/uploads/2019/10/2019-Global-Health-Security-Index.pdf

[43] The working group's membership and other details are (in Japanese) here: http://www.resilience-jp.biz/wg/wg24/

[44] The handbook (in Japanese) was updated on March 15 and is here: http://www.hosp.tohoku-mpu.ac.jp/info/information/2326/

[45] These are detailed (in Japanese) in "2020 Committee proposes 7 commitments," Nikkei Medical, February 12, 2010: https://medical.nikkeibp.co.jp/leaf/mem/pub/report/t344/202002/564278.html

[46] See Riyanti, Djalante, Rajib Shaw, and Andrew DeWit, "Building resilience against biological hazards and pandemics: COVID-19 and its implications for the Sendai Framework," Progress in Disaster Science, Vol. 6 April, 2020: https://www.sciencedirect.com/science/article/pii/S259006172030017X

[47] See "Emergency Risk Management for Health: Overview," World Health Organization, May 2013: https://www.who.int/hac/techguidance/preparedness/risk_management_overview_17may2013.pdf

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Review Article

An integrated approach to sustainable development, National Resilience, and COVID-19 responses: The case of Japan

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ABSTRACT

The COVID-19 pandemic has led to historic economic fallout. To protect public health and stabilize incomes, governments have implemented massive fiscal stimulus packages. These fiscal supports are crucial, though there is concern that sustainable and resilient development will be sacrificed in the rush to preserve incomes and industries. The aim of the paper is to review whether the Japanese governments' responses in terms of financial stimulus considers longer term resilience and sustainability. This paper reviews pertinent academic literature and publicly available data from governments and organisations. The research is a rapid analysis of emerging information provided by the government of Japan and other international organisations. Using the case of Japan, this paper suggests that it is possible both to protect public health and essential services, while also promoting resilience and sustainability. Japan's integrated solutions show that pandemic response can include accelerated decarbonization and resilient, sustainable development. The paper also warns also that failure to act on long-term sustainability risks increased inequality, higher opportunity costs, cascading hazards, and further retreat from planetary thinking and globalism.

1. Introduction

This paper begins by reviewing the global developments, then turns to the specifics of the Japanese case. We conclude with a section on strategies towards further bolstering long-term sustainability and resilience building. As to global developments, the World Health Organization (WHO) officially declared COVID-19 a pandemic on March 11, 2020 [1], and by May 15 was reporting over 3.4 million confirmed cases [2]. It soon became clear that the pandemic's social and economic impacts were accelerating with no modern precedent. Economic impacts that unfolded over a few years during the Great Depression now erupt within a few weeks. By April 18, the International Monetary Fund (IMF) had already projected the pandemic's total 2020–2021 costs to be USD 9 trillion, equivalent to the combined size of the German and Japanese economies [3]. A month later, on June 24, the IMF raised that figure to USD 12 trillion [4]. On April 7, the International Labour Organization (ILO) estimated global job losses in the second quarter (April–June) of 2020 to equate to 195 million full-time positions [5]. By June 30, the ILO had more than doubled that estimate, to 400 million [6]. These new data are almost certain to become under-estimates.

Amidst the chaos, astute global leaders have sought to articulate a collective response. On March 19 UN Secretary General Antonio Guterres warned that "[w]e are facing a global health crisis unlike any in the 75-year history of the United Nations" [7]. Guterres emphasized the imperative of solidarity, hope and a coordinated global response to counter a "human crisis" [8]. The March 26 G20 Leaders' Statement on COVID-19 from their Extraordinary Summit echoed this sentiment, declaring that "[c]ombatting this pandemic calls for a transparent, robust, coordinated, large-scale and science-based global response in the spirit of solidarity [9].

Spending programmes to cope with the pandemic's impacts have increased in scale and frequency, both multilaterally and domestically. As to the former, on March 25 the UN launched a USD 2 billion global humanitarian response plan (GHRP) to fund the fight against COVID-19 in the world's poorest countries [10]. March 26 saw the G20 pledge USD 5 trillion of stimulus (both multilateral and country-level) into the global economy, as part of targeted fiscal policy, economic measures, and guarantee schemes to counteract the pandemic's social, economic and financial impacts. On March 31, the EU Solidarity Fund's scope was broadened to include major public health emergencies. The FY 2020

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financing of roughly EUR 800 million is aimed at supporting member countries' action to protect their populations and prevent viral spread [11].

Country-level fiscal stimulus packages have been far more numerous and aggressive. Table 1 summarizes the cumulative fiscal stimulus, in currency amounts and share of GDP, for several major countries as of April 20. For example, April 7 saw the Japanese Cabinet approve the country's largest ever stimulus of JPY 108 trillion (approximately USD 1 trillion), subsequently increased to JPY 117.1 trillion on April 20. On May 26, that amount was doubled, with the total reaching JPY 234.2. Most observers expect several more stimulus packages in Japan and elsewhere as the public-health crisis worsens.

Measures to recover from the present crisis are virtually certain to include long-term investments in health, energy, water, transport, and other critical infrastructure [15]. Climate-aware individuals and institutions recognize the present crisis as an opportunity - indeed an imperative - for resilient, decarbonizing and equitable structural change. Certainly COVID-19 has dramatically reshaped the policymaking debate by: 1) bolstering public authority over private agency, 2) elevating collaborative planning over reliance on price signals, 3) expanding the scope of all-hazard resilience to emphasize pandemic risks, and 4) vastly increasing public awareness of the need for holistic resilience. Thus, back on March 31, UN Secretary General Guterres was able to insist that "[t]he recovery from the COVID-19 crisis must lead to a different economy" without attracting a flurry of criticism [16].

Yet many questions whether this ideational change will become institutionalized and lead to inclusive resilience. There is no guarantee that national-level countermeasures will come to embody the 2030 Agenda, let alone serve as a basis for productive global cooperation. There is also no consensus on precisely what constitutes best practice in decarbonizing and disaster-resilient infrastructure, and hence no simple guide for selecting and implementing such urban systems.

Many voices equate sustainability with green energy – notable solar and wind - within a context wherein "green recovery" has become the byword for transcending fossil fuels. But simply investing in more solar and wind does not seem sufficient. Data on global renewable investment between 2010-19 show that China is the leader, followed by the US and Japan [17]. But those prodigious investments alone did not reduce emissions, increase equity, and otherwise achieve the 2030 Agenda goals. Equally, if not more important, is the resource-efficiency of urban and semi-urban communities, the inclusivity of governance, and the myriad other factors that are key to the 2030 Agenda.

The scope of the challenge is underscored by International Energy Agency estimates that the COVID-19 shock - though unprecedented - will only lead to an 8% reduction in CO2 emissions in 2020, relative to 2019 [18]. To be sure, that decline in emissions accords with the call for annual CO2 reductions of 7.6% to limit warming to 1.5° [19]. But the IEA warns that 2020's decline in emissions could be followed by a massive increase unless stimulus plans emphasize low-carbon and decarbonizing recovery. Just as unprecedented economic chaos alone does not eliminate emissions, fiscal stimulus does not necessarily lead to "build back better."

Hence the urgency of examining the evidence on what countries are doing. Observers note that some countries - notably China, Germany and South Korea - are thinking of including sustainability goals in upcoming fiscal stimulus [20]. But the evidence suggests Japan is already battling COVID-19 and building climate resilience at the same time. This paper shows that Japan embeds holistic resilience and sustainability in its fiscal stimulus packages. Past and present performance indicate Japan's emphasis on integrated solutions can help accelerate decarbonization and foster resilient, sustainable development while countering COVID-19's myriad impacts. Japan is one example of how COVID-19 countermeasures are being used to bridge national and international imperatives.

The next section turns to the fiscal and institutional details of the Japanese case.

Table 1
COVID-19 fiscal stimulus, % GDP (as of July 1, 2020) [12,14].

Country	Fiscal Stimulus (Amount)	Fiscal Stimulus (% GDP)
Japan	JPY 234.2 trillion (USD 2 trillion)	42.2
US	USD 2.9 trillion	14
Germany	EUR 913 billion	26.9
France	EUR 425 billion	19
China	RMB 4.2 trillion	4.1

Source: Japanese Cabinet Secretariat [12,13]; IMF [3,4,14].

2. Japan's fiscal stimulus in context

As noted earlier, Japan's COVID-19 fiscal countermeasures total JPY 234.2 trillion as of July 1, 2020. Much expert commentary on Japan's first round of fiscal stimulus pointed to the fact that it was not all new finance, but rather built on Japan's December 2019 fiscal stimulus [21]. In other words, the criticism largely suggested that JPY 108 trillion size of Japan's April 7 fiscal stimulus was exaggerated. But this appraisal of the scale of Japan's April 2020 fiscal stimulus deflected attention from the important resilience-oriented content of the December 2019 stimulus. The December stimulus had nothing to do with COVID, and instead responded to Japan's need to further bolster holistic disaster resilience in the wake of floods, seismic events, power outages, and other shocks during 2018 and 2019. We present the main elements of the December 2019 package in Table 2.

Table 2 shows that there were three key pillars in the December 2019 stimulus: National Resilience Plans (NRP) and disaster reconstruction; economic risk countermeasures; and "Post 2020 Olympic Games" legacy investment in Society 5.0, SDGs-inclusive society. Of course, the 2020 Olympic Games are postponed to 2021, and in the end may not even be held. But that does not mean the investment in critical infrastructures is, ipso facto, wasteful.

The table also separates the JPY 13.2 trillion public spending from the JPY 26 trillion total of public and private spending. The latter figure is achieved via national government support for local government spending (through direct and indirect subsidies), low-interest loans to foster business investment, and similar mechanisms.

In terms of precise content among the three categories, the NRP share is JPY 2.8 trillion, investments in Society 5.0 and SDGs (both investment in infrastructure and training human resources) JPY 781.6 billion. The NRP projects are underpinned by the idea that "coping with climate change is also conducive to disaster prevention," and the Society 5.0/SDG initiatives explicitly target zero-emissions technology (such as natural refrigerants), energy efficiency, and related decarbonization [22].

The subsequent fiscal stimulus (cumulative to April 20) built on this legacy by doubling down on the NRP, SDGs and Society 5.0 roles. The package also included JPY 15 trillion for restructuring supply chains to re-shore or at least further diversify (eg, among ASEAN countries) the production of critical medical and related materials (pharmaceuticals, masks, ventilators, sanitizers, and other items). Moreover, consistent with the December 2019 approach, the measures undertaken in April ramp up the efforts on Society 5.0, digital transformation, decarbonization, and other measures specifically to reduce the risks of future pandemics. The package also emphasizes SDGs-style multilateral

Table 2
December 2019 Fiscal Stimulus (JPY trillion) (Source [12].

Measure	Public Spending
NRP and Disaster Reconstruction	5.8
Economic Risk	3.1
Post 2020 Olympic Games	4.3
Total	13.2

engagement on water systems, public health and other critical infrastructure via JETRO, JBIC, JICA and through UNICEF, IMF, WBG, ADB, and other agencies where Japan has a track record of close collaboration.

The above is not to insist that Japan is a leader in fighting COVID-19. In the May 7 *Financial Times* former UN Executive Secretary of the UN Framework Convention on Climate Change, Christiana Figueres, included Japan among the countries that “acted in line with the risks.” But it is also the case that, like almost all other countries, Japan’s pre-COVID all-hazard disaster resilience grossly under-estimated the risks of a pandemic. And again, like most other countries, Japan’s pandemic response was delayed and remains inadequate. Yet it is also true that Japan’s 20,261 confirmed cases and 982 fatalities as of July 9, are much lower than most of its peer countries in the G20 and OECD [23]. But in any event, this paper is not the venue to compare the relative merits of differentiated epidemiological responses to COVID-19 per se, particularly because much remains unclear about the pandemic’s trajectory and what is effective in the face of it.

3. Japan’s integrated paradigm: society 5.0, SDGs and National Resilience

3.1. Society 5.0 and national SDGs initiatives

Far more important for our purposes here is that Japan’s actions are evolving in a holistic paradigm. For one thing, they are part of an integrated, resilience-oriented “Society 5.0″ industrial policy regime that predated COVID-19 [24,25]. We saw earlier that this policy regime was already heavily funded in Japan’s pre-COVID, December 2019 stimulus. And that pre-COVID stimulus comprises a core element of the larger April 20 stimulus noted earlier. Society 5.0’s policy arms include such critical cyber-physical linkages as “post 5G” next-generation communications, remote-sensing for disaster risk reduction, digitalization in smart cities, 3-D mapping for compact cities, monitoring and controls for integrating variable renewable energy, and other means to bolster evidence-based collaborative governance [25]. Japan’s Society 5.0 is also directly tied to the 2030 Agenda’s Sustainable Development Goals (SDGs). Indeed, Japan’s SDGs initiative appears to be unique among the developed countries: its multi-level SDGs collaboration deliberately uses the SDGs’ 17 goals and 169 targets to focus local government initiatives on myriad domestic challenges in combination with overseas engagement and contributions. In short, Japan does not see SDGs as external aid but rather as a platform for integrating sustainable domestic and overseas development [26].

As is shown in Table 3, Japan has organized a broadly inclusive Local SDGs Public-Private Collaborative Platform. By the end of June, the platform included 631 local governments in addition to most of the national government’s central agencies. It also includes 1318 business firms, research institutions, NPOs and other members, bringing the total to 1962 members. Table 4 also shows the ongoing results of the Japanese Cabinet Office’s efforts to disseminate best practice. Since 2018, the Cabinet Office has opened a competition for subnational governments to be designated as SDG Future Cities and for particularly well-integrated initiative to be designated as Model Cases. As of April of 2020, there are 60 SDG Future Cities and 20 Model Cases.

A further important platform context for shaping Japanese action is its Smart City Public-Private Collaborative Platform, whose membership is itemized in Table 5. Of particular note is the growing number of local governments, at present 115. The platform also includes 120 observers, and is yet another venue in which decarbonizing and inclusive Society 5.0, SDGs, and DRR best practice are shared among a multiplicity of stakeholders.

A more recent platform is Japan’s Green Infrastructure Public-Private Collaborative Platform. The local government membership includes Sendai City (the host city for the SFDRR), Tokyo, and other influential cases. Moreover, the important role of central agencies is coupled with the participation of business, academe, NPOs and other stakeholders whose collective expertise encompasses water, energy, construction, and other areas crucial to designing and implementing comprehensive green-infrastructure solutions (Table 6).

3.2. National Resilience Plans (NRP)

One of Japan’s key governance platforms for designing, implementing and revising integrated policy is National Resilience [27]. National Resilience predates the 2030 Agenda’s Sendai Framework on Disaster Risk Reduction (SFDRR), formally adopted in 2015, but closely parallels its content by emphasizing all-hazard disaster preparation in advance, building back better, and “whole of government” inclusive governance. National Resilience also encompasses smart communications, sustainable energy systems, resilient water networks, and the other critical infrastructures that compose holistic resilience.

Japan’s national and subnational governments are closely linked in a rapidly expanding portfolio of national and subnational National Resilience Plans (NRPs) that have legal precedence over other plans. NRPs are aimed at bolstering the country’s resilience to natural disasters and other hazards, as well as fostering the capacity to recover from such disasters when they occur. Since 2014, there have been 2 iterations (2014, 2018) of the NRP Basic Plan as well as 6 annual action plans that decide and then monitor the planning cycle and the achievement of Key Performance Indicators (KPI). These KPIs include hard measures, such as monitoring hazards via smart sensors, strengthening back-up power for hospitals and other facilities, reinforcing flood-control systems, and hardening critical communications infrastructure. The KPIs also include soft measures, such as skill-building, risk communication, and measures to break down governance silos. In the 2019 revision of the original 5-year NRP basic plan, the number of KPIs had increased to 179. Moreover, Japanese National Resilience has been funded at roughly JPY 5 trillion per year since FY 2018. The investments finance soft and hard measures in addition to training and international engagement.

Table 3
Japan’s local SDGs public-private collaborative platform (as of April 2020), Source: http://future-city.go.jp/platform/.

Member Class	Number
Subnational Governments	631
Central Agencies	13
Private Firms and others	1318
Total Membership as of end June 2020	1962

Table 4
Japan’s local SDGs communities and model cases (as of April 2020) Source: https://sdgs-support.or.jp/journal/sdgs-future-city/.

Category and Year	Number
2018 SDG Future Cities	29
2018 SDG Model Cases	10
2019 SDG Future Cities	31
2019 SDG Model Cases	10
Total Cities and Cases	Cities: 60, Model Cases: 20

Table 5
Japan’s smart city public-private collaborative platform (as of June 2020) (Source: https://www.mlit.go.jp/scpf/about/index.html).

Platform Member Class	Number
Subnational Governments	115
Central Agencies	11
Businesses, Research Centres, and others	359
Business Associations	2
Total Membership	487

Table 6
Japan's green infrastructure public-private collaborative platform (as of March 19, 2020) (Source: http://www.mlit.go.jp/report/press/sogo10_hh_000216.html).

Member Class	Number
Subnational Governments	23
Central Agencies	4
Businesses, Research Centres, and others	150
Individual Memberships	232
Total Membership	409

3.3. Prefectural and cities resilience initiatives

A key test of any such ostensibly collaborative initiative is how well it diffuses and how purposefully engaged the actors are. By May 1 of 2020, all of Japan's 47 prefectures had adopted their own regional versions of the NRP. Moreover, as a Table 7 shows, 1472 of Japan's 1741 cities, special wards, and towns had either adopted their own local versions of the NRP or were formulating plans. This number of local governments doing NRPs was more than seven times the 190 total from just over a year earlier, April 1 of 2019 [12,13]. That startling 775% rate of increase in a little over a year is testament to the rapid spread of risk-awareness in Japan. Recent years of unprecedentedly destructive typhoons, floods and other disasters have led to a consensus on the need for comprehensive planning and integrated countermeasures. Japan's subnational governments now routinely request increased regular budget and special fiscal stimulus spending on NRP, SDGs, Society 5.0 projects and their integration. These fiscal and related requests are articulated collectively through such subnational representative organisations as the National Governors' Association, The National Mayors' Association and others.

An example of how the December 2019 fiscal stimulus was used at the subnational level is seen in Table 8 in Sapporo City. The table shows Sapporo's 2020 initial spend on economic stimulus, responding to the national government's December package, focused on close to JPY 19 billion for resilient and smart schools. Other spending included JPY 11.32 billion on bolstering the city's waterways, transport networks and other critical infrastructure. This emphasis on resilience is no surprise. Like many of Japan's subnational governments, Sapporo is aggressive in building on national policy to pursue integrated solutions to disaster, demographic, fiscal, and myriad other hazards. Sapporo was selected as one of the SDGs projects in June of 2018 and followed that up in December 2019 by revising the NRP it had adopted in January of 2016. Sapporo had already undertaken a Compact City Plan from March of 2016 and had also implemented a Smart City initiative from March of 2017. Sapporo is only one example of productive use of the fiscal stimulus within Japan's larger context of 2030-Agenda oriented platform institutions.

4. Towards resilience building and long-term sustainability globally

Having analysed Japan's financial stimulus in responding to COVID-19 response from section 2 to 3, we turn to examine how integrated financial and economic stimulus can foster a rights-based, low carbon, resilient and sustainable recovery. The year 2020 was slated to be the "super year" of global action toward sustainability. The SDGs - also known as the Global Goals - were adopted by all United Nations Member States in 2015 as a universal call to action to end poverty, protect the planet, and ensure that all people enjoy peace and prosperity by 2030. The 17 SDGs are integrated—that is, they recognize that action in one area will affect outcomes in others, and that development must balance social, economic and environmental sustainability. Through the pledge to Leave No One Behind, countries have committed to fast-track and prioritize progress for the most disadvantaged. That is why the SDGs are designed to achieve several 'zeros', including zero poverty, hunger, AIDS, and discrimination against women and girls. Broad stakeholder participation is needed to reach these ambitious targets. The creativity, knowhow, technology and financial resources from all elements of society are necessary to achieve the SDGs in every context. Moreover, through Nationally Determined Contribution (NDCs), countries show how they plan to meet the Paris Agreement on Climate Change [28]. In addition, the Sendai Framework for DRR calls for a comprehensive, multi-hazard and coherent approach (SFDRR, 2015).

Objectively speaking, integrating the 2030 Agenda is even more important in the midst of COVID-19. As IRENA (2020) puts it, "the goals set out in the United Nations 2030 Agenda and the Paris Agreement can serve as a compass to stay on course during this disorienting period. They can help to ensure that the short-term solutions adopted in the face of COVID-19 are in line with medium- and long-term development and climate objectives." The UN has also emphasized that the recovery from the COVID-19 crisis "must lead to a different economy" [10,16]. The International Resource Panel (IRP) has also pointed out that resource-efficient green stimulus packages can lead to cost savings, new industries, and equitable economic growth [29].

Evn so, public policy is clearly distracted by political polarization, geopolitical tensions, and other factors. In this section, we outline key implications if the fiscal response does not conform with the 2030 Agenda, both at the national level in Japan, and also globally.

4.1. Increased inequality

Emergency spending only to perpetuate the patently vulnerable status quo risks forfeiting opportunity to reduce a range of negative externalities that erode human health and welfare and have been implicated in the retreat of democracy (EIU, 2020). Concerning the US, Philip Alston, the UN Special Rapporteur on extreme poverty and human rights, pointed out that "[l]ow-income and poor people face far higher risks from the COVID-19 due to chronic neglect and discrimination, and a muddled, corporate-driven, federal response [that] has failed them" (OHCHR, 2020). The UN has also warned that coronavirus-driven debt crises threaten poor countries already at risk. It recommends accelerating investment in resilient infrastructure, strengthening social protections, enhancing regulatory frameworks, and strengthening the international financial safety net and framework for debt sustainability. And it strongly advises that this action be coordinated lest the larger opportunity be lost in the gaps among governance and other silos [30].

4.2. Higher opportunity costs

Opportunity costs are the pecuniary and other potential benefits forgone when one alternative is chosen over another. Specifically concerning fiscal countermeasures to COVID-19 and its economic fallout, failure to include climate action risks accelerated global warming. We have seen that the scale of COVID-19 counter-measures is already

Table 7
Increase in Japan's local national resilience plans (NRPs) (Source: https://www.cas.go.jp/jp/seisaku/kokudo_kyoujinka/pdf/200401_keikakumap.pdf).

Administrative Level	April 1, 2019	May 1, 2020
Local Government	190	1472

Table 8
Sapporo City's 2020 Economic Stimulus-Related Spending (unit: JPY billion) (Source: p 14 http://www.city.sapporo.jp/zaisei/kohyo/yosan-kessan/r2/documents/r2gaiyouzentai.pdf).

Disaster-Recovery and Resilience: 20.9	Resilient Schools	9.36
	Emergency Power	0.24
	Flood and Other	11.32
Future-Oriented Investment: 11.1	ICT in Schools	9.54

enormous, unprecedented in peacetime. Most countries lack the fiscal capacity and political will to continue such spending beyond one or two years, let alone for decades. Focused investment in public health systems - particularly in least developed countries - could reduce economic costs from future outbreaks as well as contribute to containing the present one [31]. For example, analyses suggest that in the US alone social distancing measures lead to net benefits of $5.2 trillion [32]. These kinds of benefits could be multiplied by making the health investments climate-smart as well.

4.3. Greater complexity and systemic risk

Global connectedness has led to increased complexity. That complexity carries with it benefits for some but at the same time a hidden cost for all: fragility (Jensen, April 9, 2020). In finance, for example, interconnected institutions benefit from complex networks and reduced transaction costs, but have produced a fragile structure through which illiquidity and insolvency can become almost virulent during periods of financial distress (Billion et al., 2012). Similarly, COVID-19's unprecedented impact is rooted in complexity and fragility. Human ecosystem encroachment has led to a per-decade tripling of outbreaks since the 1980s, including ebola, HIV, swine flu, avian flu, and other viruses. Global interconnectedness has provided more human hosts, and inequality an abundance of compromised immune systems. This systemic reality risks accelerated evolution of mutations, and underscores the imperative of leaving no one behind. Emerging infectious diseases in humans are frequently caused by pathogens originating from animal hosts, and zoonotic disease outbreaks present a major challenge to global health [33].The overlap of human security and national security clearly transcends national borders.

Climate change and disaster risk offer additional examples of systemic risks that are embedded in the complex networks of an increasingly interconnected world. The Paris Agreement on Climate Change calls for limiting warming to 2 °C and pursuing efforts for 1.5° [34]. The IPCC [35] states that delaying actions for mitigating climate change leads to worsened climate risk and even greater efforts to cope with the impacts [36]. Indeed, the global community stands at the precipice of the soft and hard limits of adaptation increases, which may increase the loss and damages from climate change [37]. The interaction between natural and human-induced disasters is increasingly evident. Natural hazards can trigger technical and societal disasters, and hence natural and non-natural risks have multiplied (UNDRR, 2019). The systemic nature of disaster risk is exacerbated by the fact that that the events can be sudden and unexpected, the impacts are interlinked, and the dynamism may change over time. Disaster risk can also be compounded, such that one even triggers subsequent events. And multiple events – or cascading catastrophes - can unfold almost simultaneously. The global community must therefore increase its capacity to build resilience through risk-informed sustainable development (UNDRR, 2019). It is crucial that the SFDRR's lessons be used to strengthening the resilience of nations and communities for dealing with the health, disasters, and climate challenges [38].

4.4. Increased risk of retreat from planetary thinking and globalism

The ongoing fiscal stimulus packages have raised deep concerns among fiscal conservatives, market liberals and others concerning overreach of tax/debt states. The nearly inevitable increases in taxation and outrage over the contents of ongoing fiscal relief (eg, for airlines) could further weaken political coalitions supporting climate action and global engagement. In order to achieve a virtuous cycle of mitigation and adaptation, stakeholder inclusion and co-benefits must be maximized in least-cost solutions. Fiscal and other resources are not infinite, and 2030 Agenda solutions have to be robust against emergent political hazards.

In this regard, we have shown that Japan's National Resilience Program has built a strong foundation for equipping Japan to respond to large-scale crises from COVID-19. Its financial stimulus is characterized by long-term consideration for national and local resilience, along with a vision of Society 5.0. Japan has a powerful track record of managing large scale crises and complex recovery from natural and man-made disasters. It offers a pertinent example of how to do integrated planning, implementation, and revision through multi-stakeholder and increasingly all-hazard platforms. Japan integration of COVID-19 countermeasures and resilience merits closer study for lessons on least-cost and synergistic mitigation and adaptation. We would also urge that Japan use it stimulus packages even more productively, as a window of opportunity for implementing long-term sustainability and resilience.

In conclusion, it is a tall order to draft and implement a coherent strategy of COVID-19 countermeasures coupled with the 2030 Agenda. Global partnerships are critical to formulating and disseminating a global response. That is why goal 17 of the SDGs centres on strengthening global partnerships among national governments, the international community, civil society, the private sector and other stakeholders. The 2030 Agenda thus embodies the shared responsibility and global solidarity essential to making COVID-19 recovery a major step in the long journey back from planetary boundaries and towards sustainable and resilient communities.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

References

[1] WHO, WHO Director-General's Opening Remarks at the Media Briefing on COVID-19 - 11 March 2020, 2020, 11 March.
[2] WHO, COVID-19 Situation Reports, 2020.
[3] IMF, World Economic Outlook, April 2020, The Great Lockdown, 2020.
[4] IMF, World Economic Outlook Update, June 2020: A Crisis like No Other, an Uncertain Recovery, 2020.
[5] ILO, ILO Monitor, COVID-19 and the World of Work, second ed., 2020 (COVID-19 and the world of work).
[6] ILO, ILO Monitor, COVID-19 and the World of Work, fifth ed., 2020 (COVID-19 and the world of work).
[7] UN HC, This Is, above All, a Human Crisis that Calls for Solidarity, 2020 (United Nations).
[8] UN Sol, Solidarity, Hope' and Coordinated Global Response Needed to Tackle COVID-19 Pandemic, Says UN Chief, 2020.
[9] G20, G20 Leaders' Statement, 2020.
[10] G.H.R.P. UN, Funding the Fight against COVID-19 in the World's Poorest Countries, 2020.
[11] EU, EU Solidarity Fund: Application Guidelines for Covid-19 Assistance, 2020.
[12] Japan Cabinet Secretariat, Economic and other countermeasures, in Japanese, 2020 (経済対策等：経済財政政策 - 内閣府).
[13] Japan Cabinet Secretariat, National resilience, in Japanese, 2020 (国土強靭化｜内□官房ホームページ).
[14] IMF, Policy Responses to COVID19, 2020.
[15] J. Lu, A Simple Way to Close the Multi-Trillion-Dollar Infrastructure Financing Gap, 15 April, the World Bank, 2020.
[16] UN, The Recovery from the COVID-19 Crisis Must Lead to a Different Economy, 31 March, 2020 (United Nations).
[17] UNEP/BNEF, Global Trends in Renewable Energy Investment 2019, Frankfurt School, 2019.
[18] IEA, The Impact of the Covid-19 Crisis on Clean Energy Progress, 2020.
[19] S. Evans, Carbon Brief, Analysis: coronavirus set to cause largest ever annual fall in CO2 emissions, 9 April, 2020.
[20] S. Hammer, S. Hallegate, World Bank, Planning for the Economic Recovery from COVID-19: A Sustainability Checklist for Policymakers, 14 April, 2020.
[21] Nobun Takemoto, Izumi Nakagawa, Focus: the COVID-19 Economic Countermeasures," Asahi Shimbun, March 23, in Japanese, 2020.
[22] Japan Cabinet Secretariat, Comprehensive economic measures to create a future with security and growth, in: December 5, 2019.
[23] Johns Hopkins University, COVID-19 Dashboard, 2020. https://www.arcgis.com/apps/opsdashboard/index.html#/bda7594740fd40299423467b48e9ecf6.
[24] Aleksandrina Mavrodieva, Rajib Shaw, Disaster and climate change issues in Japan's society 5.0—a discussion, Sustainability 12 (5) (2020).
[25] CAO, Cabinet Office of Japan, Society 5.0 (2020).
[26] Sachiko Seki, Concerning the Promotion of Japanese-Style SDGs," Governance, October, 2019, in Japanese, 2019.

[27] Andrew DeWit, Riyanti Djalante, Rajib Shaw, "Building holistic resilience: Tokyo's 2050 strategy, Asia-Pacific J. 18 (7) (2020).
[28] UNFCCC, Nationally determined contributions (NDCs), 2020.
[29] IRP, Building Resilient Societies after the Covid-19 Pandemic, 2020.
[30] UNDP, The Social and Economic Impact of Covid-19 in the Asia-Pacific Region, 2020.
[31] Warwick J. McKibbin, Roshen Fernando, The Global Macroeconomic Impacts of COVID-19: Seven Scenarios, 2020.
[32] Linda Thunstrom, Newbold Stephen, David Finnoff, Madison Ashworth, Jason F. Shogren, The benefits and costs of flattening the curve for COVID-19, 2020. Available at: SSRN 3561934.
[33] C.K. Johnson, P.L. Hitchens, P.S. Pandit, J. Rushmore, T.S. Evans, C.C. Young, M. M. Doyle, Global shifts in mammalian population trends reveal key predictors of virus spillover risk, Proceed. Roy. Soc. B 287 (1924) (2020) 20192736.
[34] Joeri Rogelj, Michel Den Elzen, Niklas Höhne, Taryn Fransen, Fekete Hanna, Harald Winkler, Roberto Schaeffer, Sha Fu, Keywan Riahi, Malte Meinshausen, Paris Agreement climate proposals need a boost to keep warming well below 2 C, Nature 534 (7609) (2016) 631–639.
[35] IPCC, Summary for policymakers, in: V. Masson-Delmotte, P. Zhai, H.O. Pörtner, D. Roberts, J. Skea, P.R. Shukla, A. Pirani, W. Moufouma-Okia, C. Péan, R. Pidcock, S. Connors, J.B.R. Matthews, Y. Chen, X. Zhou, M.I. Gomis, E. Lonnoy, T. Maycock, M. Tignor, T. Waterfield (Eds.), Global Warming of 1.5°C. An IPCC Special Report on the Impacts of Global Warming of 1.5°C above Pre-industrial Levels and Related Global Greenhouse Gas Emission Pathways, in the Context of Strengthening the Global Response to the Threat of Climate Change, Sustainable Development, and Efforts to Eradicate Poverty, 2018.
[36] O. Hoegh-Guldberg, D. Jacob, M. Bindi, S. Brown, I. Camilloni, A. Diedhiou, R. Djalante, K. Ebi, F. Engelbrecht, J. Guiot, Y. Hijioka, Impacts of 1.5 C global warming on natural and human systems, in: Global Warming of 1.5° C. An IPCC Special Report, 2018.
[37] R. Mechler, C. Singh, K. Ebi, R. Djalante, A. Thomas, R. James, P. Tschakert, et al., Loss and Damage and limits to adaptation: recent IPCC insights and implications for climate science and policy, Sustain. Sci. (2020). https://link.springer.com/content/pdf/10.1007/s11625-020-00807-9.pdf.
[38] R. Djalante, R. Shaw, A. DeWit, Building resilience against biological hazards and pandemics: COVID-19 and its implications for the Sendai Framework, Progress Disaster Sci. (2020) 100080.

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Commentary

Reflection of Challenges and Opportunities within the COVID-19 Pandemic to Include Biological Hazards into DRR Planning

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Abstract: COVID-19 has reinforced the need to revisit the integration of health within disaster risk reduction (DRR) strategies for biological hazards in a system-wide approach. In November 2020, DRR experts attended the Asia-Pacific Partnership for Disaster Risk Reduction (APP-DRR) Forum to share progress and learnings in the areas of health system resilience, data management, residual risk management, risk communication, digital literacy, and knowledge product marketing. Advancements for health in DRR included the importance of multi-sectoral, multi-hazard action plans; adaptation to technological advancements in data collection, dissemination and protection; promoting the health and wellbeing of essential and nonprofessional workers; and improving inclusivity in digital literacy. COVID-19 has affected progress towards the Sustainable Development Goals (SDG) and created a unique opportunity within DRR to re-evaluate the adequacy of response mechanisms against concurrent, cascading or interacting risks of future biological hazards. Health emergency disaster risk management (Health-EDRM) is a new World Health Organization paradigm that includes DRR at intra-, inter- and multidisciplinary levels. Scientific advancement under Health-EDRM is necessary for health and non-health actors in DRR education and research. Continuous education on the multifaceted risk governance is a key to building awareness, capacity and accelerating towards achieving the international DRR and the SDG targets.

Keywords: health-EDRM; disaster risk reduction; biological hazards; Sendai Framework; COVID-19, pandemic

1. Introduction

The intersection between health, resilience capacity building and disaster risk reduction (DRR) planning and strategies has emerged as an interdisciplinary field of great importance for the protection of human health and wellbeing [1] since the publication of several international frameworks, including the Sendai Framework for disaster risk reduction 2015–2030 [2], and more recently in World Health Organization (WHO) Framework for Health-Emergency Disaster Risk Management Framework (Health-EDRM) [3]. The ongoing COVID-19 pandemic has amplified the need to bring the health sector front-and-center in disaster risk management at national and international levels. A hazard is defined by the United Nations Office for Disaster Risk Reduction (UNDRR) within the Hyogo Framework for Action as "a potentially damaging physical event, phenomenon or human activity that may cause the loss of life or injury, property damage, social and economic disruption or environmental degradation. Hazards can include latent conditions that may represent future threats and can have different origins: natural (geological, hydrometeorological and biological) or induced by human processes (environmental degradation and technological hazards)" [4]. A pandemic is an example of a biological hazard, which are hazards that may be either "of organic origin or conveyed by biological vectors", would be further defined by characteristics such as "infectiousness or toxicity, dose–response, incubation period, case fatality rate and estimation of the pathogen for transmission" [5], and may have amplified impacts in the age of globalization.

Globally, hazard management planning and response strategies have yet to reflect the non-linear transition of biological hazards, particularly pandemics, which can emerge in overlapping waves with different impacts, and the community must enter a response phase before the initial recovery phase is completed [6]. As a result, the non-linear attributes of biological hazards have rendered the human community vulnerable to protracted crises that persist and increase the community's vulnerability to the cascading risks of multi-hazard that generate complex secondary events and interactions [7]. Many global at-risk communities face cumulative impacts of concurrent geological and hydrometeorological hazard events like earthquakes and cyclones during the COVID-19 pandemic, exacerbating existing issues of food insecurity and social security. Examples of multi-hazards with cascading risks include the cyclone Amphan landfall in India and Bangladesh, which disrupted clean water and sanitation systems, leading to barriers in adequate hand-washing and hygiene, which has, in turn, exacerbated not only the spread of COVID-19 but other waterborne diseases [8]. The Philippines experiences an average of twenty tropical typhoons annually, which has added burden to the emergency situation of the country, leaving many communities to rely on their own resources for protection as local government resources are spent responding to COVID-19 [9]. In addition, many vulnerable communities are affected by syndemics—the concurrent, cascading or interacting risks of biological hazards within the same individuals and groups, thereby aggravating disease burdens such as COVID-19 and an array of noncommunicable diseases [10]. The inadequacy of available risk strategies catered for the nuances of biological hazards will undoubtedly challenge the resilience of community health and health systems.

2. Materials and Methods

This paper delineates the key issues as highlighted at the Asia-Pacific Partnership for Disaster Risk Reduction (APP-DRR) Forum (December 2020) convened by the United Nations Office for Disaster Risk Reduction (UNDRR) Regional office for Asia and the Pacific. This is a multi-stakeholder forum that includes governments, regional inter-governmental organizations, civil society organizations, international organizations and donor organizations. The purpose of the discussions is to monitor the implementation of the Sendai Framework across the region and for stakeholders to share community-relevant insights and identify key priority action areas towards DRR in the region [11].

The way forward for health system resilience building, data management, residual risk management, risk communications, digital literacy, and knowledge product marketing were priority areas identified in this forum and are discussed in this paper.

3. Results

3.1. Health System Resilience

When responding to a biological hazard, the health sector is expected to lead the immediate frontline response. In response to the multifaceted impacts of COVID-19, many jurisdictions mobilized resources outside of the health sector to impose control measures against the spread of the virus, which brought in travel, tourism, education, and other sectors. The most common measures included personal behavioral regulations such as mandatory face masks in public places [12]; social distancing like city lockdowns, quarantine, and school closures [13–15]. Other measures include emergency international travel guidelines, such as self-declaration of health status, and mandatory COVID-19 testing [16–18]. Although the Sendai Framework calls for the broader health system vigilance and resilience and to integrate disaster risk management across primary, secondary, and tertiary healthcare, there is a discord in how national responses are organized to respond to COVID-19. Japan, for example, has a dedicated National Action Plan for Pandemic Influenza and New Infectious Diseases (2013) [19], which provides multi-sectoral, holistic and comprehensive recommendations from the pre-outbreak to the recovery phase. The national action plan proactively monitors outbreaks in other areas of the world, and recommends international joint simulation exercises in the pre-outbreak phase. The plan contains recommendations to ensure continuity of medical care, of education, welfare-services, and business recovery mechanisms. The plan, however, does not consider concurrent, cascading or interacting hazards [6]. In contrast, Singapore's national Pandemic Readiness and Response Plan for Influenza and Other Acute Respiratory Diseases (2014) [20] aims to mitigate the mortality and morbidity consequences after the onset of the first wave through rigid surveillance. The plan mobilizes essential services, case monitoring and isolation mechanisms, and infection control in hospitals so as to maintain healthcare provision. However, the plan is developed by the Ministry of Health and heavily emphasizes the healthcare and public health approach, but is limited in considering the role and responsibility of other sectors [6]. While these plans include guidance on post-epidemic surveillance and the lifting of social and economic restrictions to return to normalcy, neither of these plans takes into consideration the mitigation or treatment of long-term physical, social and psychological impacts of a pandemic, which can include symptoms of anxiety, depression and even posttraumatic stress among healthcare workers or the wider population [21]. In the case of COVID-19, there is evidence of post-viral syndrome, which can include fatigue, myalgia, headaches and shortness of breath [22].

Most of these communities have a primary focus on building resilient health systems and building capacity within health workers to apply DRR approaches in service delivery [2]. Nevertheless, there are broader aspects to consider:

- The capacity of the relevant health and non-health workers across the entire pathway of care should be strengthened, from screening, testing, diagnosis, treatment, recovery and rehabilitation [6];
- Surveillance and information systems must be strengthened to ensure that data collected includes all populations and will enable the system to identify and protect groups facing vulnerability [6];
- Public–private partnership models for health service provision should be explored and promoted to maximize functionality and service provision, especially when government systems are constrained [6].

3.2. Data Management

Biological hazards affect population groups differently, depending on their exposure. Vulnerability will vary according to the nature of the hazard, existing mitigation and protection systems, and any existing and inherent risks faced. Traditional groups facing vulnerability include, but are not limited to, older people, groups living in rural areas, migrant groups, indigenous groups, and those with comorbidities, physical or mental disabilities. In order to assess impact inclusively, baseline pre-disaster data for health and socioeconomic indicators should be made available to identify and minimize the impact of determinants that may exacerbate biological risks [6]. To achieve DRR that is inclusive of the vulnerable and the forgotten, risk assessments during emergency settings must therefore include disaggregated data and analysis for groups facing vulnerabilities such that policies may holistically address the risks of the entire community.

Meanwhile, efforts will be needed to address the challenges in data storage, monetization of data, ethics related to secondary use of data, and implications on personal protection. While sharing timely and accurate data is necessary to the response and containment to a global pandemic, stringent protocols for the secure storage and distribution of data must be implemented, which consider access rights, encryption and continuous review of security, which take into account the evolving benchmark for security and technological advancements [23]. Global data platforms such as Google, Facebook, Uber and cell phone companies have in the past monetized data, for example, in making geolocation data available to scientists for disease spread modeling or similar research. In the case of COVID-19, such information has been utilized for contact tracing or controlling population access to public spaces. In addition, a clear protocol for the management of secondary data is necessary to guarantee a balance between privacy and the usefulness of data [24]. Personal protection is important, and includes mechanisms for identity protection, protection against discrimination, understanding how personal data are used, and informed consent prior to data collection, particularly if the information collected can reveal information related to the health of the individual or their family [25].

3.3. Residual Risk Management

The global response to COVID-19 has highlighted essential workers as a highly exposed group with unique needs. The categorization of essential services varies between jurisdictions, across workforces from healthcare, social work, government services, agriculture, transport, waste management and others. However, despite society's reliance on essential workers, many have been unprotected, working under inadequate health and safety conditions, and putting themselves and their families at risk [26,27]. In many communities, duties of care and protection have been undertaken by nonprofessionals such as informal home care providers [28]. There is a gendered impact of increasing reliance on informal care, which is provided by women in many communities. School closures in Asia, for example, are impacting professional women differently, who provide informal care within families. Travel restrictions have caused challenges and uncertainties to foreign domestic workers, many of whom are women [29]. Informal care providers are often not directly protected by legal measures for health protection or adequate infectious disease control training [30]. In Muslim communities, evidence has shown that women are more likely to wear face coverings in public for religious reasons, but not in their houses while caring for others, while men wear masks for hygiene both inside and outdoors [31]. In identifying and monitoring groups facing vulnerabilities, protection mechanisms can support informal care providers through alternative means like the provision of material resources such as personal protective equipment, medicines; information resources such as home care guidelines; and appropriate training so that they may be able to care for other sick or at-risk groups while minimizing their risk and exposure [6,28].

Under COVID-19, health sectors across countries have resorted to the basic means of service and functionality. The International Labor Organization has published a policy framework on protecting the workforce during the pandemic, which encompasses areas of employment stimulation, supporting enterprises, worker protection and social dialog for solutions [32]. The International Monetary Fund has conducted research on the implication of fiscal policy measures on income inequality within and between vulnerable groups, including essential workers [33]. However, there is little discussion, experience-sharing, and evidence-based lessons learned on the health impact this protract crisis has on essential or nonprofessional workers. With all the new challenges posed by megacities, migration, rural urbanization and technological advancement, what constitutes "essential" workers in a community must be revisited and defined for relevant DRR planning and capacity building.

3.4. Risk Communication

Risk communication can only be made effective when taking the "whole of government, whole of society" approach [3]. The global impact of biological hazards highlights the importance of effective communication between stakeholders at all levels, from the international level, among experts and policymakers, to the community level, within the general public, within households, and among individuals. As the fundamental component to enhancing community cooperation, mobilization and resilience, risk communication should include a top-down approach from government or authorities that participate in cross-country dialog to enable early and effective warning systems. These warning systems should trigger national or international standard operating procedures to mitigate the impact as early as possible [3,6]. Communication also requires the bottom-up input of the whole society to ensure that the information disseminated is tailored and relevant to all members of society and their protection. Efforts should be taken to extend this dialog to groups facing vulnerability, such as indigenous communities, migrants and refugees, for whom information transfer tends to be complex and indirect. The participation and engagement of local government, faith-based groups and religious leaders, as well as civil society groups, are essential in this process [6]. Moreover, it should be recognized that resource information channels vary with user demographics, acceptability, and access. Studies have shown that health literacy and risk perception are negatively correlated with income, education and social status. The European Health Literacy Survey conducted in eight countries demonstrated that 50% of adults have problematic or inadequate levels of access, understanding, appraisal and application of health or risk information [34,35]. A study in Australia showed that people with low health literacy and people whose native language is not English demonstrated poorer understanding of COVID-19 symptoms and prevention measures, more difficulty accessing government information, difficulty accessing prescription medication, and experienced greater anxiousness and financial difficulties [36]. Studies conducted in Australia and the United States showed that factors increasing vulnerability to COVID-19, such as age, underlying chronic diseases, and income are also factors associated with the ability to access and understand health information and decision-making [36,37]. During the COVID-19 pandemic and widespread lockdown, digital media has become a convenient and rapid tool for people to gain information. It is important that risk communication ensure equitable access and understanding by all groups and mitigate against misinformation.

3.5. Digital Literacy

There is growing discussion on the use and functionality of digital tools for information-sharing, contact tracing, and communication. The rapid development of innovative information and communications technology (ICT) has enabled and enhanced the capacity for large-scale data collection, analysis and dissemination. As exemplified during COVID-19, such systems have allowed individuals to remotely conduct normative daily tasks and maintain social cohesion despite extreme physical distancing measures [38]. ICT allows sectors to continue their basic functions, such as the health sector using telemedicine for non-essential patients, the education sector using remote learning, and the business sector to promote teleworking. Furthermore, technology has enabled sectors to conduct extraordinary functions in the context of a pandemic beyond national jurisdiction. For example, governments and private entities have implemented efficient surveillance, reporting, or contact tracing through artificial intelligence other technologies that aggregate and share large-scale data; mapping disease spread for community protection [24].

However, in adopting ICT measures, careful considerations must be made to ensure digital tools are inclusive to all members of the community. For example, barriers of access and adaptability must be considered within ICT infrastructure to guarantee access to information and services among the elderly, disabled groups, lower-income households, or those living in remote areas [6].

3.6. Knowledge Product Marketing

Updating and generating new recommendations and tools for DRR is a continuous process. Outside of science, these tools can be used to develop effective public communication strategies and raising awareness for community preparedness [6]. The DRR community requires more tools and knowledge-sharing platforms to facilitate planning and strategy development [2], and there is as yet limited availability of updated and relevant DRR knowledge product specialization for biological hazards at a global scale such as the COVID-19 hazards. This has hindered knowledge sharing, scenario planning, and cross-sectoral learning. Although the WHO Thematic Platform for Health-EDRM was formed in September 2016 to "coordinate activities, promote information-sharing, develop partnerships, and provide technical advice to strengthen the Health-EDRM research field", as of 2020, there remains an urgent need to strengthen multidisciplinary learning and collaborative efforts to maximize the impact of such knowledge development. Active engagement in shared knowledge and building understanding of the complex nature of biological hazards will enable the DRR community to develop and facilitate scientific risk assessment mechanisms so as to build resilient systems in the future [3].

4. Discussion

The COVID-19 pandemic has had devastating human and socioeconomic impacts worldwide. The global attention received for COVID-19 provides an opportunity for the health and DRR communities to reconceptualize knowledge and tools for disaster risk mitigation, response and recovery. In November 2020, DRR experts from the Asia-Pacific region attended the Asia-Pacific Partnership for Disaster Risk Reduction (APP-DRR) Forum to share progress, policy priorities and opportunities thus far for DRR in the region with respect to the COVID-19 pandemic [11]. Experts shared learnings for risk governance, including health system resilience; data management; residual risk management, risk communication, digital literacy, and knowledge product marketing. Special academic attention has been paid regarding the integration of biological hazards into DRR planning [6]. Although the Health-EDRM Framework was established to ensure that health will be considered within the DRR dialog at intra, inter and multidisciplinary levels, further efforts are required to ensure that both health and non-health actors in education and continuous education are included within DRR frameworks. Notably, and urgently, to include students and young professionals who will become key stakeholders in the next decade in promoting awareness, scientific development, policy, and capacity at the intersection of health and DRR. Successful implementation of the Sendai Framework will require updated Health-EDRM and DRR tools that consider concurrent, cascading and interacting hazards. Cascading risks have a serious impact on national action plans, and the impacts faced are becoming increasingly complex and interdependent. However, national plans still tend to focus on the most probable impacts rather than on those that will bring the most complex consequences that require heavily coherent and coordinated response [7]. Adaptive governance mechanisms are necessary for building interdependent resilience cutting across social, institutional, economic and ecological levels. Reinforcing continuous learning and innovation across the governance of different sectors will strengthen DRR outcomes [39], systematic risks analysis and related action planning. Table 1 summarizes how the above discussion may expand into and impact DRR, related challenges and suggested solutions.

The COVID-19 pandemic has demonstrated the ability for a biological hazard to travel across national borders and the need for governance structures mitigating against transnational risks. There is a role for North-South, and South-South collaboration in jointly developing technological, medical and social innovations, which can accommodate local variation, that lead to creating incentivization for long-term multi-generational resilience [40]. Inter-sectoral coordination such as public–private partnership models for health service provision should be explored to maximize the functionality of service provision and the range of services available [6].

There is a large number of activities, priorities and stakeholders that must be mobilized, facilitated, and coordinated, not only in response to the pandemic and in the recovery phase but also in developing DRR plans against the next hazard that emphasizes a coordinated response across linked sectors rather than over-burdening one sector [6]. In order to operationalize lessons learned in impactful, cost-effective and sustainable ways, methods in cross-program planning, monitoring and evaluation can be taken from the area of project management. This will involve viewing international development as a transformative public sector project when evaluating delivery constraints such as time, cost and quality. International development and private sector projects are at risk of facing similar challenges in poor stakeholder management, cost overruns, inadequate monitoring, and lack of understanding of local context. However, international development projects often have less tangible goals and certainly face higher socio-political complexities that induce further transaction costs [41].

Table 1. Opportunities for different areas to expand into and impact disaster risk reduction (DRR), related challenges and suggested solutions.

Issues	Opportunities to Expand into DRR	Challenges	Suggested Solution
Health systems resilience	• Strengthen health considerations within multi-sectoral national or international DRR action plans • Improve hazard-related health outcomes by revaluating the resilience and vigilance of the health system as a whole	• Weaknesses in current action plans that do not consider the entire disaster cycle or prepare for concurrent, cascading or interacting risks • Weaknesses in current action plans that do not consider multi-sectoral impact or response • Weaknesses in current action plans that do not consider post-epidemic long-term physiological or psychological effects • National bodies are creating unique, siloed national action plans that lack complementarity	• Develop multi-hazard, multi-sectoral and adaptive action plans for DRR • Consider health systems-wide paradigm to care, beyond clinical care • Reinforce awareness-building and continuing professional education as a key component in policy development
Data management	• Identify areas of improvement in existing data platforms (collection, storage, analysis, sharing) in terms of: - Inclusivity of vulnerable groups - Compatibility with other DRR information platforms - Compatibility with technological advancement • Unique opportunity to collect robust post-pandemic data across all populations, to be used in recovery assessment research or for future hazards	• Security considerations in terms of data storage and management • Ethical considerations for data use, monetization of data, and personal data protection	• Consider inclusivity and representation of vulnerable groups in building data management tools • Incorporate the latest technological advancement and adaptive capacities for piloting secure data collection and data management tools • Continuous education regarding systems development and updates
Residual risk management	• Define or redefine "essential" groups, including part-time workers, nonprofessionals (e.g., home care	• There is no standard definition of "essential" workers or nonprofessional workers	• Develop policy and guidelines to protect essential workers and nonprofessional workers

	givers), and non-health sector workers		
	• Research into health impact and health needs of a pandemic on essential workers and nonprofessional workers, in order to build evidence-based policy and guidelines	• Lacking recognition or political will to protect the health and wellbeing of these groups (e.g., material provision, information dissemination)	• Data and research in health impact and needs of essential workers and nonprofessional groups including needs in material resources, information gaps, or training opportunities • Continuous education of stakeholders involved in policy update and development
Risk communication	• Review or strengthen top-down government approaches to early warning systems • Consider health literacy in disaster risk communication and decision-making frameworks • Consider demographic and health factors (e.g., old age, physical disabilities) in ability access to information	• Limited evidence of barriers to inclusivity of populations or inclusivity of communication channels • Limited but growing political will in managing misinformation or in determining the reliability of the information	• Develop inclusive platforms for information dissemination (e.g., used by the elderly, disabled individuals) • Community dialog to review and research barriers of information access and understanding • Building awareness and appropriate policies for communities facing vulnerabilities and improving patterns of communication under complex circumstances
Digital literacy	• Use of novel technology to develop tools for DRR data management (e.g., information sharing, data collection, tracking) • Use novel technology to improve health DRR (e.g., diagnostics, telemedicine)	• Complex access to digital tools for certain groups (e.g., elderly, remote/rural groups, low-income groups)	• Build community dialog to promote the use of digital tools and understand barriers to usage • Pilot novel and innovative tools for telemedicine, robotic temperature monitoring, or automated dispensary • Building awareness and appropriate policies for communities facing vulnerabilities and improving patterns

			of communication under complex circumstances
Knowledge product marketing	• Update Health-EDRM and DRR tools, in particular, to consider the multifaceted and adaptive nature of concurrent, cascading and interacting hazards • Multi-sectoral participation in the development of updated tools and guidelines	• Lack of political or institutional will for multi-sectoral planning	• Collect evidence and lessons learned for needs in addressing novel biological hazards • Develop adaptive tools and knowledge products • Begin a multi-sectoral dialog for DRR • Building awareness and identifying knowledge gaps within communities to encourage active research and policy development

5. Conclusions

COVID-19 has impacted progress across the Sustainable Development Goals (SDG). The economic impact has resulted in an estimated 71 million people pushed into extreme poverty (SDG 1—no poverty); 80 million children under the age of 1 are estimated to miss routine vaccinations (SDG 3—good health and wellbeing); school closures will affect 90% of students (SDG 4—quality education); cases of domestic violence will increase in 30% of countries (SDG 5—gender equality); and 60% of countries will experience prison overcrowding and further risk of spreading COVID-19 (SDG 16—peace, justice and strong institutions) [40].

However, the pandemic also creates opportunities to strengthen SDG, such as strengthening partnerships under SDG 17 in developing shared warning mechanisms, data sharing, multi-stakeholder partnerships in science to build evidence-based policy recommendations. These partnerships can be built between sectors of a country, but also in North–South or South–South cooperation [6].

Opportunities and resources available during the response and recovery of the COVID-19 pandemic may allow DRR stakeholders to examine and evaluate systemic weaknesses in a holistic and comprehensive manner. To ensure that the global population would be more sufficiently protected against future concurrent, cascading, or even interacting hazards, revisiting current DRR plans and strategies within the current framework of biological hazards will be instrumental. The COVID-19 pandemic has created a chance to strengthen partnerships; build mechanisms for a coordinated response between DRR experts and counterparts in health; and build health as a core component across disaster prevention, mitigation, response and recovery. Building understanding of the multifaceted and adaptive components of risk governance within people in their formative years will allow the next-generation to accelerate towards achieving the targets under the Sendai Framework as well as the SDGs. Continuous education, notably of students and young professionals, may be a key component when building awareness about DRR.

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References

1. Chan, E.Y.Y.; Shaw, R. *Health and Disasters: Health Emergency and Disaster Risk Management in Asia*; Shaw, R., Ed.; Springer: Singapore, 2020; ISBN 9780323286657.
2. United Nations International Strategy for Disaster Reduction. *Sendai Framework for Disaster Risk Reduction 2015–2030*; United Nations International Strategy for Disaster Reduction, Geneva, Switzerland, 2015.
3. World Health Organization. *Health Emergency and Disaster Risk Management Framework*; World Health Organization: Geneva, Switzerland, 2019; ISBN 9789241516181.
4. United Nations International Strategy for Disaster Reduction. *Hyogo Framework for Action 2005-2015: Building the Resilience of Nations and Communities to Disasters*; United Nations International Strategy for Disaster Reduction,, Geneva, Switzerland, 2005.
5. United Nations General Assembly. *Report of the Open-Ended Intergovernmental Expert Working Group on Indicators and Terminology Relating to Disaster Risk Reduction*; United Nations, Geneva, Switzerland, 2016; Volume A/71/644.
6. Shaw, R.; Chatterjee, R.; Dabral, A. *Integrating Biological Hazards (Including Pandemics) into DRR Planning: Technical Advisory Document*; unpublished, 2020. Available online: http://www.ccouc.ox.ac.uk/technical-advisory-document-integrating-

biological-hazards-including-pandemics-into-drr-planning (accessed on 21 December 2020).
7. United Nations International Strategy for Disaster Reduction. *Cross-Sectoral and Multi-Risk Approach to Cascading Disasters*; United Nations International Strategy for Disaster Reduction, Geneva, Switzerland, 2017.
8. Ebrahim, S.H.; Rahman, N.M.M.; Imtiaz, R.; Gozzer, E.; Alqahtani, S.A.; Ahmed, Y.; Memish, Z.A. Forward planning for disaster-related mass gatherings amid COVID-19. *Lancet Planet. Health* **2020**, *4*, e379–e380, doi:10.1016/S2542-5196(20)30175-3.
9. Lucero-Prisno, D.E.; Bernardino, G.D.; Camua, A.A.R.; Lin, X.; Adebisi, Y.A. Philippines braces for the typhoon season amidst COVID-19. *Lancet Reg. Health West. Pac.* **2020**, *1*, 100003, doi:10.1016/j.lanwpc.2020.100003.
10. Singer, M.; Bulled, N.; Ostrach, B.; Mendenhall, E. Syndemics and the biosoical concepts of health. *Lancet* **2017**, *389*, 941–950, doi:10.1016/S0140-6736(17)30003-X.
11. United Nations Office for Disaster Risk Reduction Asia-Pacific Partnership for Disaster Risk Reduction (APP-DRR) Forum. Available online: https://www.undrr.org/event/asia-pacific-partnership-disaster-risk-reduction-app-drr-forum-0 (accessed on 27 January 2021).
12. World Health Organization. *Mask Use in the Context of COVID-19*; World Health Organization: Geneva, Switzerland, 2020.
13. Public Health England Guidance on Shielding and protecting People Who are Clinically Extremely Vulnerable from COVID-19. Available online: https://www.gov.uk/government/publications/guidance-on-shielding-and-protecting-extremely-vulnerable-persons-from-covid-19/guidance-on-shielding-and-protecting-extremely-vulnerable-persons-from-covid-19 (accessed on 21 December 2020).
14. Government of Hong Kong New Requirements to Reduce Gatherings. Available online: https://www.coronavirus.gov.hk/eng/reduce-gatherings.html (accessed on 21 December 2020).
15. Centers for Disease Control and Prevention Operating Schools during COVID-19: CDC's Consideration. Available online: https://www.cdc.gov/coronavirus/2019-ncov/community/schools-childcare/schools.html (accessed on 21 December 2020).
16. Government of Hong Kong Points to Note for Quarantine for Inbound Travellers. Available online: https://www.coronavirus.gov.hk/eng/inbound-travel.html (accessed on 21 December 2020).
17. Singapore Ministry of Health Updates on Border Measures and Community Surveillance Testing Operations. Available online: https://www.moh.gov.sg/news-highlights/details/updates-on-border-measures-and-community-surveillance-testing-operations (accessed on 21 December 2020).
18. Public Health England Coronavirus (COVID-19): Safer Travel Guidance for Passengers. Available online: https://www.gov.uk/guidance/coronavirus-covid-19-safer-travel-guidance-for-passengers (accessed on 21 December 2020).
19. Government of Japan National Action Plan for Pandemic Influenza and New Infectious Diseases. Available online: https://www.cas.go.jp/jp/seisaku/ful/keikaku/pdf/national action plan.pdf (accessed on 22 December 2020).
20. Singapore Ministry of Health Pandemic Readiness and Response Plan for Influenza and Other Acute Respiratory Diseases. Available online: https://www.moh.gov.sg/docs/librariesprovider5/diseases-updates/interim-pandemic-plan-public-ver-_april-2014.pdf (accessed on 22 December 2020).
21. Gallagher, M.W.; Zvolensky, M.J.; Long, L.J.; Rogers, A.H.; Garey, L. The Impact of Covid-19 Experiences and Associated Stress on Anxiety, Depression, and Functional Impairment in American Adults. *Cognit. Ther. Res.* **2020**, *44*, 1043–1051, doi:10.1007/s10608-020-10143-y.
22. Davido, B.; Seang, S.; Tubiana, R.; de Truchis, P. Post–COVID-19 chronic symptoms: A postinfectious entity? *Clin. Microbiol. Infect.* **2020**, *26*, 1448–1449, doi:10.1016/j.cmi.2020.07.028.
23. Dubois, C.; Wright, K.; Parker, M. Ethics in Research. In *WHO Guidance on Research Methods for Health Emergency and Disaster Risk Management*; World Health Organization: Geneva, Switzerland, 2020; pp. 185–199.
24. Findlay, M.J.; Remolina, N. Regulating Personal Data Usage in COVID-19 Control Conditions. *SSRN Electron. J.* **2020**, 1–42, doi:10.2139/ssrn.3607706.
25. World Health Organisation Ethics in Epidemics, Emergencies and Disasters: Research, Surveillance and Patient Care. 2015. https://www.who.int/ethics/publications/epidemics-emergencies-research/en/ Available online: (accessed on 22 December 2020).
26. McNicholas, C.; Poydock, M. Who are Essential Workers? Available online: https://www.epi.org/blog/who-are-essential-workers-a-comprehensive-look-at-their-wages-demographics-and-unionization-rates/ (accessed on 22 December 2020).
27. Lancet, T. The Lancet The plight of essential workers during the COVID-19 pandemic. *Lancet* **2020**, *395*, 1587, doi:10.1016/S0140-6736(20)31200-9.
28. Chan, E.Y.Y.; Gobat, N.; Kim, J.H.; Newnham, E.A.; Huang, Z.; Hung, H.; Dubois, C.; Hung, K.K.C.; Wong, E.L.Y.; Wong, S.Y.S. Informal home care providers: The forgotten health-care workers during the COVID-19 pandemic. *Lancet* **2020**, *395*, 1957–1959, doi:10.1016/S0140-6736(20)31254-X.
29. Wenham, C.; Smith, J.; Morgan, R. COVID-19: The gendered impacts of the outbreak. *Lancet* **2020**, *395*, 846–848, doi:10.1016/S0140-6736(20)30526-2.
30. Karlsson, U.; Fraenkel, C.-J. COVID-19: Risks to healthcare workers and their families. *Br. Med. J.* **2020**, *371*, doi:10.1136/bmj.m3944.
31. Yonally, E.; Tulloch, O.; Butler, N.; Gillespie, A. *RCCE Strategies to Overcome Covid-19 Fatigue in the Eastern Mediterranean, Middle Eastern and Northern Africa*; Institute of Development Studies, Brighton, UK, 2020.
32. International Labour Organization. *A Policy Framework for Tackling the Economic and Social Impact of the COVID-19 Crisis*; International Labour Organization, Geneva, Switzerland, 2020.

33. Jurzyk, E.; Nair, M.M.; Pouokam, N.; Sedik, T.S.; Tan, A.; Yakadina, I.; Tan, A.; Yakadina, I. *COVID-19 and Inequality in Asia: Breaking the Vicious Cycle*; International Monetary Fund, Washington, DC, USA, 2020.
34. Okan, O.; Bollweg, T.M.; Berens, E.M.; Hurrelmann, K.; Bauer, U.; Schaeffer, D. Coronavirus-related health literacy: A cross-sectional study in adults during the COVID-19 infodemic in Germany. *Int. J. Environ. Res. Public Health* **2020**, *17*, 5503, doi:10.3390/ijerph17155503.
35. Sørensen, K.; Pelikan, J.M.; Röthlin, F.; Ganahl, K.; Slonska, Z.; Doyle, G.; Fullam, J.; Kondilis, B.; Agrafiotis, D.; Uiters, E.; et al. Health literacy in Europe: Comparative results of the European health literacy survey (HLS-EU). *Eur. J. Public Health* **2015**, *25*, 1053–1058, doi:10.1093/eurpub/ckv043.
36. McCaffery, K.; Dodd, R.; Cvejic, E.; Ayre, J.; Batcup, C.; Isautier, J.; Copp, T.; Bonner, C.; Pickles, K.; Nickel, B.; et al. Health literacy and disparities in COVID-19–related knowledge, attitudes, beliefs and behaviours in Australia. *Public Health Res. Pract.* **2020**, *30*, 1–9, doi:10.17061/phrp30342012.
37. Wolf, M.S.; Serper, M.; Opsasnick, L.; O'Conor, R.M.; Curtis, L.; Benavente, J.Y.; Wismer, G.; Batio, S.; Eifler, M.; Zheng, P.; et al. Awareness, Attitudes, and Actions Related to COVID-19 Among Adults with Chronic Conditions at the Onset of the U.S. Outbreak: A Cross-sectional Survey. *Ann. Intern. Med.* **2020**, *173*, 100–109, doi:10.7326/M20-1239.
38. World Health Organization Digital Technology for COVID-19 Response. Available online: https://www.who.int/news/item/03-04-2020-digital-technology-for-covid-19-response (accessed on 21 December 2020).
39. Munene, M.B.; Swartling, Å.G.; Thomalla, F. Adaptive governance as a catalyst for transforming the relationship between development and disaster risk through the Sendai Framework? *Int. J. Disaster Risk Reduct.* **2018**, *28*, 653–663, doi:10.1016/j.ijdrr.2018.01.021.
40. United Nations. *UN Research Roadmap for the COVID-19 Recovery*; United Nations, Geneva, Switzerland, 2020.
41. Ika, L.A.; Söderlund, J.; Munro, L.T.; Landoni, P. Cross-learning between project management and international development: Analysis and research agenda. *Int. J. Proj. Manag.* **2020**, *38*, 548–558, doi:10.1016/j.ijproman.2020.10.005.

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Invited ViewPoint

Ecosystem-centric business continuity planning (eco-centric BCP): A post COVID19 new normal

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ABSTRACT

This article views the COVID-19 pandemic as an opportunity leading to a significant reduction in pollution levels, clean waters in rivers, improved visibility, and other tangible benefit to humanity and the environment. In Post-COVID scenario, to restore the margins and regain the lost production, industries are likely to increase their production leading to a quantum jump in the pollution levels. Having precedence of such a scenario in 2008–09, this article looks at what are the possible avenues to engage the city government and business houses through an a new normal ECO-BCP concept for long term sustainability. All economic stimulus needs to be tied down with the stringent reduction in the emission norms. The Ten Principles for the Eco-centric BCP guide the reopening of MSMEs after lockdown period called to check the spread of the COVID-19 pandemic. The Eco-centric BCP model will help the MSMEs to adopt the new-normal business strategies to align with the country-specific commitments to SDGs, SFDRR and Paris declaration.

1. Introduction

The COVID-19 pandemic's impact on lives and livelihoods globally are beyond measure as the war against the Virus is continuing. Involving more than 210 countries, more than 428,652 deaths, and about 7.7 million people infected and are still continuing [20 www.Worldometers.org on 13th June 2020], the pandemic is looming large on us. This is the first global crisis, threatening human existence, after World War II. A stated mortality rate of 3.4% [21] is much more than seasonal flu's mortality rate. The world was unprepared for this pandemic crisis, and global cooperation at initial stages was negligible. In the absence of any readily available medication and vaccine for the Virus, shortage in preventive gears in the face of a highly contagious virus, all combined to make this public health emergency into a worldwide epidemic. The Governments world over had to take the hard decision to save the lives of the citizens by enforcing lockdown or mass testing first to identify the affected persons [22]. Keeping economic growth was common second priority.

Cities, Industries and businesses are in turmoil [3]. The Micro, Small and Medium Enterprises (MSMEs) are always at risk, and as a result, they will bear the maximum brunt of the pandemic [1,5]. This has resulted in migration, loss of livelihood mainly for the contract and daily wagers and an uncertain future. The MSMEs had not catered to the fall out of such a highly contagious health emergency.

Past experience of pandemic recovery has shown an increase in production, reclaiming more land for production among other measures to make up for the losses. While making even with the economic losses is important but at the same time, balancing the burden on the environment is important. Recovery from this grim scenario needs to have balanced approaches to reach targets set by entities differently. This article considers the present pandemic as an opportunity to drive economic growth and support livelihood while at the same time, protect the ecosystem and promote wellbeing in the society through an Ecosystem-centric Business Continuity Plan (Eco-centric BCP) model. Analysis of secondary literature has led to the development of the conceptual framework and principles for 'Eco-centric BCP'. The following section delves into relevant literature. Based on this, Sections 3, 4, and 5 presents the conceptual framework, ten principles and strategies for adopting Eco-centric BCP. The penultimate section discusses the possible approaches and integration of the

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ECO-centric BCP concept leading to a series of recommendations for the future.

2. Literature review

A 'Business Continuity Planning' (BCP) aims to prepare for, provide to and maintain control and capabilities for managing organisations' overall ability to continue to operate during disruptions. It establishes strategic objectives and guiding principles for the organisation, and is expected to integrate safe industrial standards for affluent and emission for resilience. A report of the International Labour Organisation [8] discussed the four pillars (4Ps) model to develop a BCP: People (safety and security), Process (internal organisational processes like supply chain, logistical planning), Profit (management of risks to products/services) and Partnerships. With the huge loss of life and capital, the COVID-19 pandemic demonstrates the incredible capacity of societies to stand together to fight against unprecedented, insurmountable challenges and adapt [12].

In the high-level meeting on climate and sustainable during the 73rd session of UN General Assembly, the General Assembly President stated that people have a decade left to combat the worse impact of the climate crisis and recent improvement of the environment set an example that change in approach can show the tangible result [18]. Many businesses that have "in-person transactions" and "foot traffic" model are struggling the most due to nation-wide lockdown, even though the demand remained strong [17]. Countries throughout the world are announcing special economic packages as India announced to spend about 10%, and Japan 20% of the GDP [4,16] globally around $7 trillion in total committed as a relief package until now [13]. In the post-COVID scenario, to restore the margins and regain the lost production, the industry is likely to increase its production rapidly leading to a quantum jump in pollution levels. Significant reduction in emissions and working towards sustainability may be a wise idea even from a financial point of view [14,15]. Present health crisis and economic consequences of COVID-19 and climate crisis need to be reflected once the business entities conceptualise their BCP [19].

The COVID-19 has redefined the use and design of the public space, utility services in the urban centres. These factors directly or indirectly have a bearing on the business continuity. The real estates and the construction industry will need to come up with a design and legal solutions on building interface with public health. The planning of green spaces, mass transits, industrial units and office space design needs a to revisited and coming up with a set of guidelines to integrate the health component into urban planning and design would be necessary [6].

The countries are focusing on reviving the economy and experts are suggesting that protecting nature can prevent future pandemics; so a parallel approach should be more effective to address COVID-19 pandemic and climate crisis [12]. Learning from the recovery plan and policies of the financial crisis of the year 2008–09, governments are adopting approaches in their guidelines, many of the effective solutions have a concern regarding environmental protection [13]. The German government chose to continue climate protection through helping companies in recovery with setting incentives for reducing carbon emission, promoting modern technologies and renewable energies while announcing economic packages for various sectors [10].

Palahi et al. [11] recommend that any new model framework needs to include transformative policies, purposeful innovations, risk-taking capability, as well as the sustainable business market. Further, they suggest replacing the current economic indicators such as GDP to sustainable wellbeing as an index for a sustainable society. Recently-developed UNDRR and ADPC toolkit [17] to support MSMEs focus on the protection of employees, protection of the business and utilisation of resources available. Similarly, ILO has advocated developing an effective risk and contingency system for any business after a due diligent review of the 4Ps, risk and vulnerability profile and opportunities [8]. ILO proposed toolkit platform in a report about a 'Network of Networks' facility that can help sustainable & resilient enterprises (SRE) to keep on working in conflicts and disaster-prone areas [9]. The tool enables the MSMEs to be adaptive, customisable and flexible. It focuses on four aspects, namely- decent work supporting Sustainable Development Goal (SDG) 8, promoting positive approach supporting SDG 16, prevention from a crisis, and finally generating investment through private sectors. In these anthropocentric guidelines, the ecosystem discussion is silent.

Media Information confirms [2] that there is a significant decrease in air pollution level due to lockdown China has recorded a 25% reduction in CO_2 emission, which can save about 77,000 lives. In Venice, the water in the canals cleared and experienced more water flow and visibility of fish reported by the government [2]. The social media is flooded with photographs showing clean skies and wild animals roaming around in urban centres. The pandemic provides a unique opportunity to transit our business models towards the ecosystem-centric new-normal sustainable approach.

3. Conceptual framework for ECO-centric BCP

The Sendai Framework, Sustainable Development Goals and the Paris agreement all aim for a sustainable society. Carrying forward the discussion from Section 2, the ECO-centric BCP concept rests on four parameters namely; Parameter-1 Reduction in emission from the industry; Parameter-2 sustainable use and reuse of ecosystem services; Parameter-3 Legislation and implementation, and Parameter-4 Sustainable energy usage and consumption (Fig. 1). While the industry is the centre for providing goods and services, /driving economic growth by providing livelihood opportunities, a sustainable model of business operation will reduce the chances of failure in the supply chain by ensuring available resource in the market and stabilising the cost of procurement. These can be achieved by investing in science and technology and promoting innovation.

Further, comprehensive risk assessment to factor in issues arising due to environmental impact might be beyond the individual business's capability to manage. The recovery planning needs to envision the possible impact of action taken in the post-pandemic phase. This would have a significant impact on the secondary sphere of influence which will help in having access to clean water due to reduced affluent, better health and wellbeing due to reduced emission rates and stable livelihood. In the long-term, this will lead to gender equality, support quality education and address issues of poverty and hunger. It is important to note a scale of influence, where a local action can influence the tertiary sphere at a subnational or national scale.

4. Ten principles of the ECO-centric BCP model

The participatory and reconciliatory attitude, as mentioned by [13] and [11] is the core concept of the new Eco-Centric BCP model. To address the gap areas identified in Section 2, the Eco-centric BCP model proposes reorganised 4Ps to boost economic and ecosystem functions both; they are People, Process, Facility (infrastructure, machinery, finance and partnership) and Technology (including improvisation and innovations). To infuse MSMEs' business continuity, ten strategic guiding principles for 4Ps are proposed (Fig. 2).

5. Adopting ECO-BCP

This section identifies various ways of adopting the Eco-centric-BCP model for ground application.

5.1. Cluster concept

Business continuity for the private sector is directly linked with the essential services provided by the city. Local government is a service provider for its citizens and a custodian of the ecosystem services in its jurisdiction. ECO-BCP concept applies to both city services and business sector. At the city level, the Eco-BCP will aim at maintaining low energy consumption and sustainable use of its various natural resources. A possible approach for doing that is by integrating the Eco-BCP as an integral component of the ongoing urban-centric mission being undertaken by the Indian

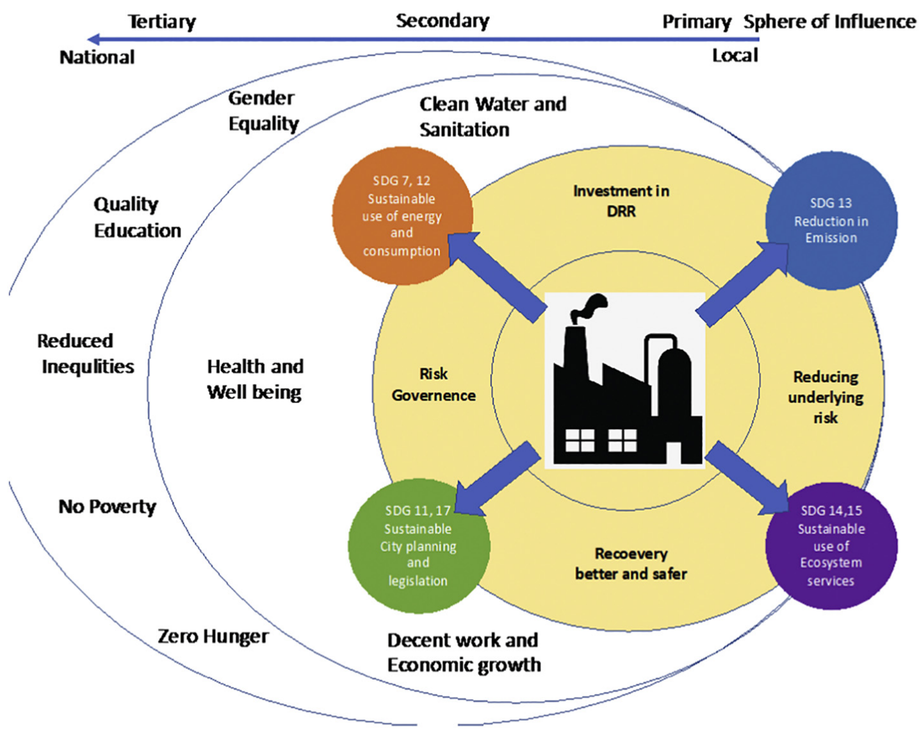

Fig. 1. Conceptual Framework for the 'Eco-centric BCP' connecting SFDRR and SDGs.

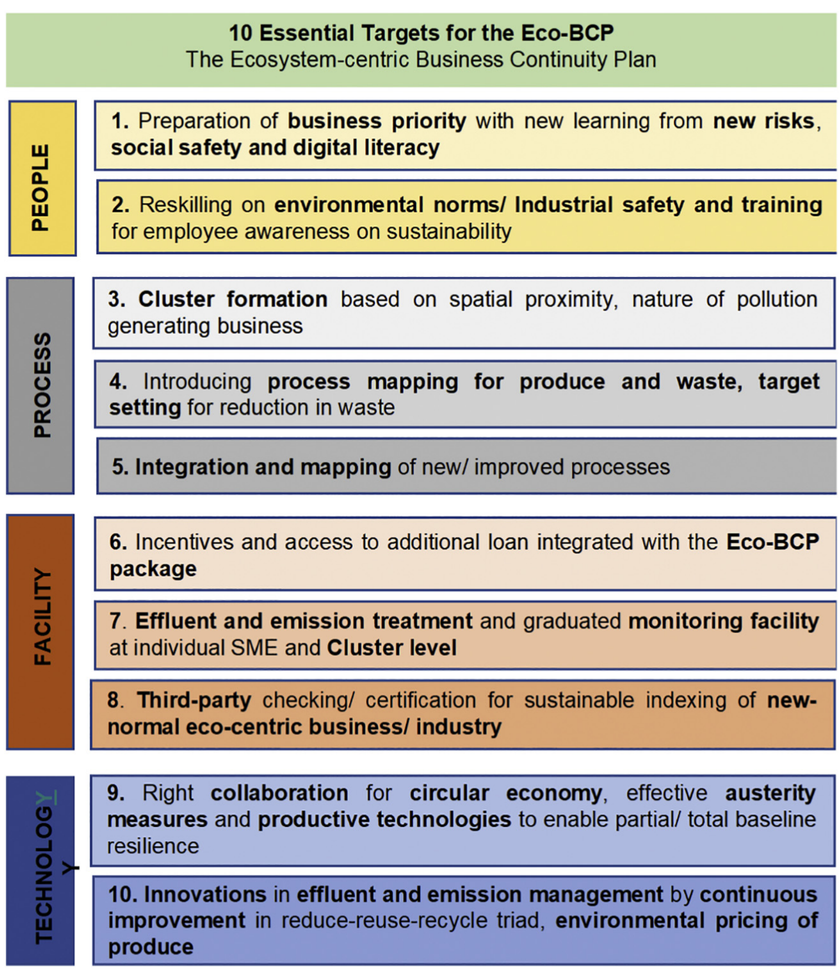

Fig. 2. The Ten Principles of the Eco-centric BCP Model.

government. In normal times the reduction of CO2 emission, sustainable use of ecosystem services, providing undisruptive basic services and lowering energy consumption is the onus of the city governance. A combination of Business Continuity Planning (BCP) and Life Continuity Planning (LCP) is needed to continue these dimensions in case of an emergency situation for safeguarding life and critical assets while ensuring energy independence (Fig. 3). While dealing with the private sector, especially the MSMEs, two approaches of Individual and Cluster Eco-BCP [7] may be adopted depending on the size and capacity of the MSMEs to boost Economic and Ecosystem Functions. The Cluster BCP will ensure continuity of MSMEs, Community and immediate environment in a group for small scale MSMEs, who as an individual organisation, may not be able to prepare or adopt a BCP. Such clusters can be at ward level in cities or can also happen within further smaller clusters who mutually share the vision for a greener future.

5.2. Graduated adoption

The natural ecosystems, even when severely constrained in urban areas, continuously provide our ecosystem- and resilience services through their ecosystem functions. Graduated Standard Operating Protocol (SOP) adoption to control the flow of emissions and throw of effluents to the ambient ecospheres of air, water, and soil shall be in place. The industries shall adopt the moderate to stringent targets, based on the potential level of industrial wastes' harmful impact and waste treatment standards practised by the said Industries. Fig. 4 explains the concept of target selection.

5.3. Scalability

The inclusive approach within the industry community, starting from top to the last post in the chain need to take responsibilities and initiatives to allow this change to happen. Major handholding needs to come from relevant government ministries at national to local levels, through their organisational arms for policy and planning backup, fiscal policies like access to easy-term loan, subsidies and incentives in terms of a tax rebate. Industrial and business associations, large and medium industries can extend technical support for retrofitting, skilling, training, advanced gears and technology sharing and graduated SOP for the new-normal Eco-centric BCP including reporting protocol, 3rd party inspection. Corporate Social Responsibilities (CSR) components can incentivise the paradigm shift. Networked initiatives among multi-actors will be required to bring the change in Industrial environment (Fig. 5).

6. Discussion

Accelerated economic activity without any string of environmental concerns will worsen pollution condition. Most of the money inflow to revive

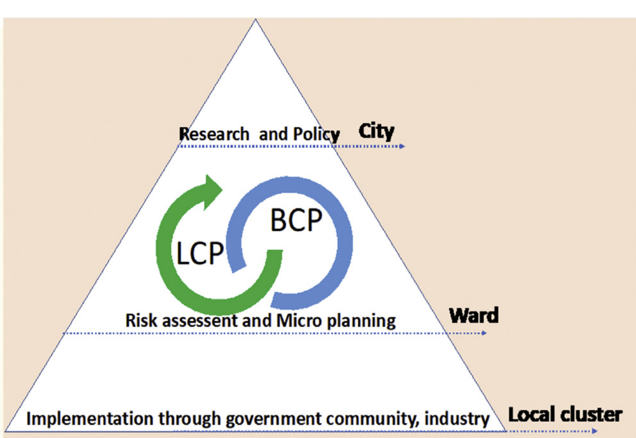

Fig. 3. Level of Services and Plan Activators during Covid 19 Pandemic.

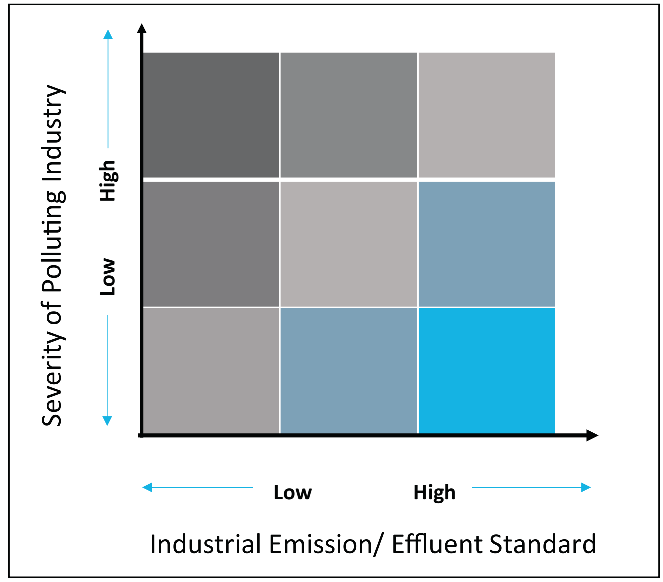

Fig. 4. Graduated SOP target adoption based on the level of polluting industry to control emissions and effluents throw in the ambient ecosphere.

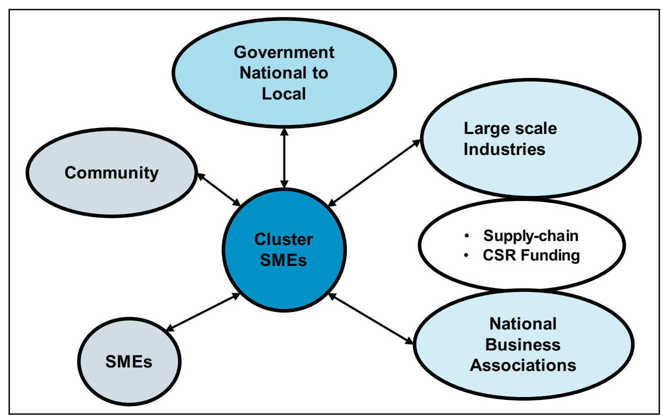

Fig. 5. Networked Chain of Activities and Actors for the scalability of MSMEs' Eco-centric BCP.

the economy has focused on increasing liquidity in global markets without any environment strings attached [13]. An eco-centric approach, an opportunity to produce differently and to help other ecosystems to survive, can serve as a paradigm shift in the investment plan (economic packages) for the 21st-century public services. The authorities need to create incentives for public and public privates industries to direct their investment in the Eco-centric BCP model.

Apart from liquidity measures, industrial bodies need to go for policy formation with major climate benefits such as clean energy and infrastructure, disaster preparedness, zero-carbon transportation etc. All economic stimulus needs to be tied down with the stringent reduction in the emission norms. It is important to ensure funds from the public sources to the objectives of the SDGs and Climate change mitigation while creating jobs and kick-starting economic activity. The rejoined sense of common good for humanity and the environment to be utilised to build a more resilient and sustainable economy by adopting the Eco-centric BCP approach for MSMEs. The Eco-centric BCP model shall not aim to come back to Business as Usual (BaU) level but to recover better. Cities need to identify clusters with possible high emission rates post lockdown and urge sustainable use of ecosystem services, especially water in drought and water scare areas. Integrating the climate-sensitive city planning, restoration of a heritage built forms and ecosystems, etc.

A strong political will and sense of urgency are required towards this critical aspect of integrating scientific advice on sustainability and climate change into policies and guidelines to protect the environment along with rejuvenating the economy. The Eco-centric BCP model will help the MSMEs to adopt the new-normal business strategies to align with the country-specific commitments to SDGs, SFDRR and Paris declaration. The adaptation to new norms and swift change shown by the global community in behaviour and functioning has no precedence in history. This encouraging spirit of collective action towards common goals must be unlisted by sensitising every stakeholder about commitment towards climate change. The Ten Principles for the Eco-centric BCP guide reopening of MSMEs after lockdown period called to check the spread of the COVID-19 pandemic.

Circular economy, alternate green jobs like ecotourism, afforestation, integrated water management shall be Post-Covid MSME sectors getting prime attention from investors. Developing a new normal in the MSME sector will require staggered lifting of the lockdown period with conditional written commitment from the individual industrial units to follow safety practices guidelines. A strong penal and monitoring regime is needed for making these norms non-negotiable. Replacing the BaU recovery plan with robust Eco-centric BCP model will require strong support from service providers who can provide support in terms of financial, technical, managerial, policy and planning. The ecosystem centric BCP planning will be the new normal to boost the economy and the ecosystem functions in the days to come.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

References

[1] Chatterjee R, Okazaki K. In: Pal I, Meding J, Shrestha S, Ahmed I, Gajendran T, editors. Risk Governance and the Role of Informal Sector in Disaster Recovery: The Case of 2015 Nepal Earthquake Chapter: Chapter 4. Springer; 2020.

[2] CNN Travel Blog. https://edition.cnn.com/travel/article/jellyfish-venice/index.html; 2020.

[3] Boissay F, Rungcharoenkitkul P. Macroeconomic Effects of Covid-19: An Early Review BIS Bulletins. accessed online at https://www.bis.org/publ/bisbull07.pdf; 2020.

[4] FICCI. http://www.ficci.in/ficci-in-news-page.asp?nid=20956; 2020. March 26, 2020, Accessed on 20 April 2020.

[5] GAR 13 Report (Global Assssment Report). UNDRR; 2013 accessed at https://www.preventionweb.net/english/hyogo/gar/2013/en/gar-pdf/GAR2013_EN.pdf.

[6] Honey-Roses J, Anguelovski I, Bohigas J, Chireh V, Daher C, Konijnendijk C, et al. The Impact of COVID-19 on Public Space: A Review of the Emerging Questions; 2020, April 21. https://doi.org/10.31219/osf.io/rf7xa.

[7] JICA Report Natural Disaster Risk Assessment and Area Business Continuity Plan Formulation for Industrial Agglomerated Areas in the ASEAN Region. Accessed online at https://openjicareport.jica.go.jp/pdf/12235677.pdf; 2015.

[8] ILO. The Six-Step COVID-19 Business Continuity Plan for SMEs. no. April: 1–12 https://www.ilo.org/wcmsp5/groups/public/—ed_dialogue/—act_emp/documents/publication/wcms_740375.pdf; 2020.

[9] ILO. Overview: Supporting Enterprises in Disaster Prone Areas, The Sustainable and Resilient Enterprises Platform. International Labour Organization; 2020; 1–4https://conflictdisaster.org/covid19-resilience-toolkit/#141-disaster-resilience-dr/Overview-Disaster-Toolkit.pdf.

[10] Nienaber M, Wacket M. Reuters Article: Germany's Merkel Wants Green Recovery From Coronavirus Crisis. https://www.reuters.com/article/us-climate-change-accord-germany/germanys-merkel-wants-green-recovery-from-coronavirus-crisis; 2020.

[11] Palahí M, et al. Investing in nature to transform the post COVID-19 economy: a 10-point action plan to create a circular bioeconomy devoted to sustainable wellbeing. Sotutions J. 2020;11(2) https://www.thesolutionsjournal.com/article/investing-nature-transform-post-covid-19-economy-10-point-action-plan-create-circular-bioeconomy-devoted-sustainable-wellbeing/. Accessed online at.

[12] Price K. Natural Conservation Blog. https://www.conservation.org/blog/what-does-covid-19-have-to-do-with-nature-these-5-articles-explain; 2020.

[13] Rathi A. Blomeberg News Article: Green Stimulus Finds Support From G-20 Officials, Central Bankers. bloomberg.com/news/articles/2020-05-04/world-s-economists-agree-economic-stimulus-ought-to-be-green; 2020.

[14] Stern N. Stern Review on The Economics of Climate Change (pre-publication edition). Executive Summary; 2006 Accessed.

[15] Teske, et al. Achieving the Paris Climate Agreement Goals, Institute for Sustainable Futures 2018. www.oneearth.uts.edu.au; 2018.

[16] Times of India (TOI). In Comparison: India's Stimulus Package vs Rest of the World; 2020 accessed at https://timesofindia.indiatimes.com/world/in-comparison-indias-stimulus-package-vs-rest-of-the-world/articleshow/75710393.cms on 15th June 2020.

[17] UNDRR, ADPC. Small Business Continuity and Recovery Planning Toolkit. United Nations Office for Disaster Risk Reduction for Aisia and Pacific and ADPC; 2020 http://www.adpc.net/igo/category/ID1583/doc/2020-r74Yp1-ADPC-COVID19_Small_Business_Continuity_and_Recovery_Planning_Toolkit.pdf.

[18] UN Press. https://www.un.org/press/en/2019/ga12131.doc.htm; 2019.

[19] Vis P. Planting the seeds of a Green Economic Recovery After Covid-19. Euractive article https://www.euractiv.com/section/energy-environment/opinion/planting-the-seeds-of-a-green-economic-recovery-after-covid-19; 2020.

[20] Worldometer. www.Worldometers.info. Accessed on June 13, 2020.

[21] World Health Organisation. WHO Director-General's Opening Remarks at the Media Briefing on COVID-19. 3 March 2020 https://www.who.int/dg/speeches/detail/who-director-general-s-opening-remarks-atthe-media-briefing-on-covid-19—3-march-2020; 2020. Accessed on April 15 2020.

[22] Djalante R, Shaw R, Dewit A. Building resilience against biological hazards and pandemics: COVID-19 and its implications for the Sendai Framework. Prog Disaster Sci. 2020.

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Article

Identifying Research Trends and Gaps in the Context of COVID-19

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Abstract: The COVID-19 pandemic has affected the world in different ways. Not only are people's lives and livelihoods affected, but the virus has also affected people's lifestyles. In the research sector, there have been significant changes, and new research is coming very strongly in the related fields of virology and epidemiology. Similar trends were observed after the Severe Acute Respiratory Syndrome Coronavirus (SARS-CoV) and Middle East Respiratory Syndrome Coronavirus (MERS-CoV) episodes of 2003 and 2012, respectively. Analyzing 20 years of published scientific papers, this article points out the highlights of coronavirus-related research. Significant progress is observed in the past research related to virology, epidemiology, infectious diseases among others. However, in research linked to public health, its governance, technology, and risk communication there seem to be gap areas. Although the World Health Organization (WHO) global research road map has identified social science-related research as a priority area, more focus needs to be given in the upcoming days for multi, cross and trans-disciplinary research related to public health and disaster risk reduction.

Keywords: coronavirus research trends; COVID-19; public health and disaster risk reduction; social science research; public health preparedness; mitigation; response and recover; World Health Organization research roadmap

1. Introduction

The coronavirus disease COVID-19 was declared a pandemic by the World Health Organization (WHO) on the 11th of March 2020, within less than three months after its first report in Wuhan, China in late December 2019 [1]. The numbers (infected people, death, number of new cases, among others) are increasing on a daily basis. From China, the hotspots shifted first to Europe and then to the USA. Many countries have declared indefinite to time-bound lock downs, with severe restrictions on in-country as well as international travel. Tremendous pressure is mounting on countries' health care systems and health care professionals are also becoming direct victim of the virus in many cases, with reported deaths in several countries.

Three major characteristics of COVID-19 are: (1) high rate of spread, (2) aged and low immunity people are more vulnerable to be infected, and (3) differential recovery rates in different countries [2]. While the urgent need is to develop the appropriate curative medicines and vaccines, there are different types of ongoing research on this topic. Pandemic risk is not just a medical issue, but has strong socio-economic, behavioral, psycho-social, governance and technological implications. Of course, virology, medical science, epidemiology are the core for addressing the key issue. However, these also need to be linked to other issues. Governance and decision-making related to pandemic risk are important points, which need to be discussed more.

Incorporation of pandemic/biological hazard risk in the Sendai Framework of disaster risk reduction is important [3], and it is mentioned that the global framework can be well linked with the health emergency and disaster risk management (H-EDRM) concept. We also see different governance-related decisions in East Asia which were effective in different stages of the pandemic [2]. Similarly, different innovative technologies have been used for pandemic response in different countries. A comprehensive review of the technology and its innovative use for serving different types of services during lock-down is yet to be done. People's behavior is one of the key aspects of pandemic response. Risk perception, understanding and communication are also linked to behavior change. New research would come out on the behavior as well as social changes during pandemics. There are also tremendous economic implications of the pandemic, which can be observed at global, regional, national and local levels. Some of the economic issues are also linked to the local social issues, especially for micro-, small- and medium-enterprises (MSMEs).

Keeping this in mind, this paper makes a modest attempt to analyze past and current research trends related to coronavirus over a period of 20 years. Detailed analysis and discussions are provided from the papers published in last three months. The analysis shows some gaps and issues, which needs to be linked to the global research road map of WHO [4].

2. WHO Research Road Map

On 30 January 2020, following the recommendations of the Emergency Committee, the WHO Director General declared that the COVID-19 outbreak constituted a Public Health Emergency of International Concern (PHEIC). World experts on COVID-19 met at the WHO headquarters in Geneva from the 11 to 12 February 2020, to assess the current level of knowledge about the new virus, agree on critical research questions that needed to be answered urgently and ways to work together to accelerate and fund priority research that can contribute to curtail this outbreak and prepare for future outbreaks [4]. The global imperative for the research community is to maintain a high-level discussion platform which enables consensus on strategic directions, nurtures scientific collaborations and, supports optimal and rapid research to address crucial gaps, without duplication of efforts. Experts identified key knowledge gaps, and research priorities and shared scientific data on ongoing research, thereby accelerating the generation of critical scientific information to contribute to the control the COVID-19 emergency. Eight immediate research actions were proposed as follows:

- Mobilize research on rapid point of care diagnostics for use at the community level
- Immediately assess available data to learn what standard of care approaches from China and elsewhere are the most effective.
- Evaluate as fast as possible the effect of adjunctive and supportive therapies.
- Optimize use of protective equipment and other infection prevention and control measures in health care and community settings.
- Review all evidence available to identify animal host(s), to prevent continued spillover and to better understand the virus transmissibility in different contexts over time, the severity of disease and who is more susceptible to infection.
- Accelerate the evaluation of investigational therapeutics and vaccine using "Master Protocols".
- Maintain a high degree of communication and interaction among funders so that critical research is implemented.
- Broadly and rapidly share virus materials, clinical samples and data for immediate public health purposes.

The target of the WHO Research Road Map was: (1) to ensure that the affected people gets proper diagnosis and optimum care, and (2) to support research priorities that lead to development of global research platform. A cross-cutting, inter-disciplinary approach was suggested which looks at the ethical aspects, as well as practical implications with international solidarity.

Nine specific thematic areas were suggested as follows:

- Virus: natural history, transmission and diagnostics.

- Animal and environmental research on the virus origin, and management measures at the human-animal interface.
- Epidemiological studies.
- Clinical characterization and management.
- Infection prevention and control, including health care workers' protection.
- Candidate therapeutics research and development
- Candidate vaccines research development
- Ethical considerations for research.
- Social sciences in the outbreak response.

Thus, broadly speaking there are three categories of research areas: (1) Science and technology (related to the virus, animals, the environment and epidemiology); (2) Governance and management (clinical management, health care worker's protection, ethical issues); (3) Social and behavior issues (people and citizen's response behavior).

In their recent book, [5] has argued the challenges and gaps in H-EDRM. The WHO pointed out in 2019 that H-EDRM remains as a fragmented nascent field, and needs to be developed as a coherent enterprise. Key challenges include non-alignment of research tools, lack of a strategic overarching research agenda, sub-optimal development of multisectoral and interdisciplinary approaches, absence of the science-policy-practice nexus, deficiency in standardized terminology, and meagre coordination among stakeholders [6]. It is interesting to note that the road map of WHO for COVID-19 makes no mention of H-EDRM. This issue will be discussed later.

3. Methodology

To understand the research trends, the Web of Science core collection database was used to search for SCIE and SSCI papers related to coronavirus published in 2000–2019. The search formula was defined as "TS = Coronavirus", and the language was set to English. In November 2002 Severe Acute Respiratory Syndrome Coronavirus (SARS-CoV) broke out in Guangdong, China, and became an acute epidemic in 2003. Middle East Respiratory Syndrome Coronavirus (MERS-CoV) is reported in Saudi Arabia in 2012 and has since spread to different countries.

In this analysis, twenty years (2000 to 2019) have been broken into five time slices: 2000–2003, 2004–2007, 2008–2011, 2012–2015, and 2016–2019. See Table 1 for the main information about the publication situation in each time period.

Table 1. Main information of the relevant coronavirus publications between the year of 2000 and 2019.

Time Period	2000–2003	2004–2007	2008–2011	2012–2015	2016–2019
Number of Publications	848	2706	1824	2446	2786
Source journals	226	599	511	585	645
Author keywords	881	2911	2881	3278	4610
Average citations per documents	57.32	39.96	31.24	26.41	7.19
Authors of single-authored documents	56	131	69	133	91
Authors of multi-authored documents	2624	8944	6940	9617	11,886
Collaboration Index	3.36	3.51	3.97	4.22	4.43

In order to analyze the evolution characteristics of coronavirus research topics over time, a word cloud was used to reflect the dominant topics during each period. A 'word cloud' is a visual representation of word frequency. The more commonly a term appears within the text being analyzed, the larger the word appears in the generated image. Word clouds are increasingly being employed as a simple tool to identify the focus of written material [7]. Also, co-word analysis [8–10] was used to construct a co-occurrence map to reveal the research hotspots and evolution of each time slice. Co-word analysis is used in a longitudinal framework which allows us to analyze and track the evolution of a research field along consecutive time periods [8]. Additionally, it develops a performance analysis of specific themes using different basic bibliometric indicators.

Author keywords are a list of terms that authors believe best represent the content of their papers. In the following study, the hot topics of each time slice are visualized by building the word cloud of author keywords. Since titles and abstracts can interpret the contents of paper more comprehensively than keywords, terms extracted from titles and abstracts are used to construct the co-word map by VOSviewer and the topic clusters of each time slice are analyzed based on the co-word map.

4. Research Trends Until 2019

4.1. Time Period: 2000–2003

From 2000 to 2003, the frequency of SARS occurrences was 141, and the total cited frequency was 11,723. That is to say, the SARS research in 2003 has received widespread attention worldwide (Figure 1). In addition, the research frequency of HEPATITIS (a type of disease) during this period is also very high, 65 times, and the total cited frequency is 2544. The research on HEPATITIS is basically based on Mouse. From the statistical results, the hot topics in 2000–2003 shown in Table 2.

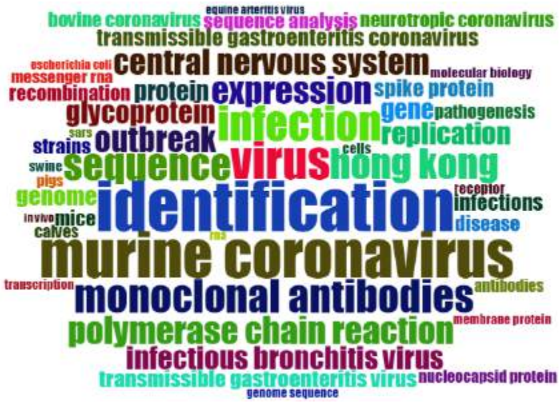

Figure 1. Keywords Cloud Map of 2000–2003.

Table 2. Items and frequency of hot keywords between 2000–2003.

Item	Frequency	Year
CORONAVIRUS	168	2003
MOUSE HEPATITIS-VIRUS	137	2001
IDENTIFICATION	90	2003
MURINE CORONAVIRUS	82	2001
ACUTE RESPIRATORY SYNDROME	69	2003
VIRUS	67	2002
INFECTION	62	2001
MONOCLONAL-ANTIBODIES	59	2001
SEQUENCE	58	2002
HONG-KONG	55	2003
EXPRESSION	49	2002
OUTBREAK	46	2003
CENTRAL-NERVOUS-SYSTEM	45	2001
GLYCOPROTEIN	40	2002
PROTEIN	35	2002
RESPIRATORY SYNCYTIAL VIRUS	10	2000
MESSENGER-RNAS	10	2000
PACKAGING SIGNAL	7	2000
RECOMBINANT VACCINIA VIRUS	7	2000
BROME MOSAIC-VIRUS	6	2000
MURINE CORONAVIRUSES	6	2000
MAMMALIAN-CELLS	6	2000

There are two papers cited over 150 times during 2000–2003, one is written by Luo et al. (2000) published in *Journal of Virology*, titled "Retargeting of coronavirus by substitution of the spike glycoprotein ectodomain: crossing the host cell species barrier". The other is written by Lane et al. (2000) also published in *Journal of Virology*, titled "A central role for CD4(+)T cells and RANTES in virus-induced central nervous system inflammation and demyelination".

VOSViewer is adopted to construct the terms cooccurrence map. Terms are extracted from the title and abstract fields, the minimum number of occurrences of a term is set as 10, and a relevance score is calculated for each term. Based on the score, the 60% most relevant terms are selected to build the cooccurrence map (Figure 2). Blue clusters are studies of SARS cases, and the red clusters are studies of proteins and genes. The yellow clusters are studies of mouse hepatitis; and the green clusters are studies of antibody chain reactions. The analysis shows a strong presence of red clusters (protein and gene). The inter-disciplinary nature of the research, which is required, may not be that strong.

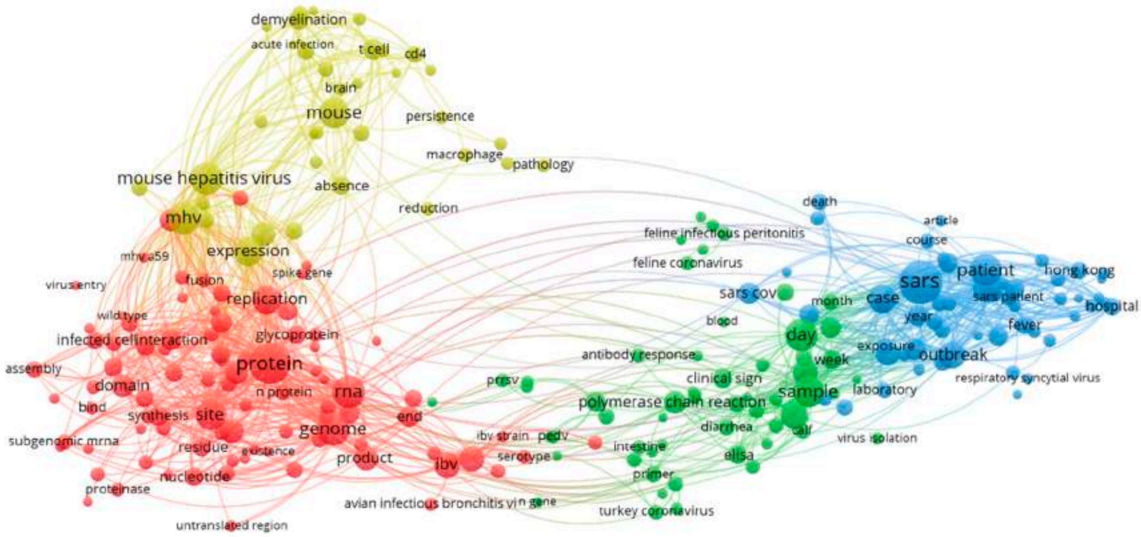

Figure 2. 2000–2003 term co-occurrence map.

4.2. Time Period: 2004–2007

From 2004 to 2007, SARS has become a research focus and focus, with 977 occurrences and 29,584 total citations (Figure 3).

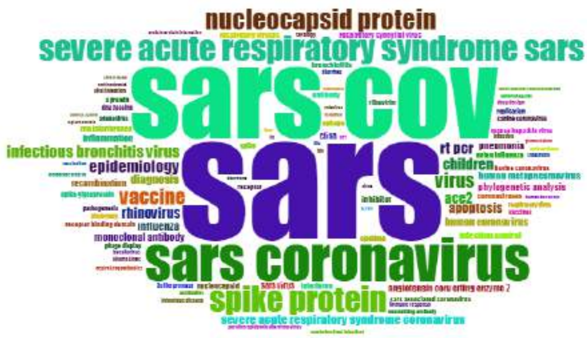

Figure 3. Keywords cloud map of 2004–2007.

"Protein" occurred 490 times with 14,994 citations, of which "spike protein" appeared 184 times and was cited 7155 times. In addition, "patients" appear 137 times, with 5108 citations, "nucleocapsid" appears 120 times, and its frequency of citations reached 3622 times. The hot topics in 2004–2007 extracted from the statistical results are shown in Table 3. It is noted that there are seven articles that were cited more than 500 times between 2004 and 2007. The information is shown in the Table 4.

Table 3. Items and frequency of hot keywords during 2004–2007.

Item	Frequency	Year
INFECTION CONTROL	12	2004
TREATMENT	8	2004
CHEMOKINES	8	2004
CORTICOSTEROID	7	2004
ZOONOSIS	6	2004
TURKEY CORONAVIRUS	6	2004
MULTIPLE SCLEROSIS	6	2004
S GLYCOPROTEIN	6	2004
MOUSE	6	2004
QUARANTINE	6	2004
CORONAVIRUS	242	2005
SARS	212	2005
SEVERE ACUTE RESPIRATORY SYNDROME	171	2005
SARS CORONAVIRUS	64	2005
SEVERE ACUTE RESPIRATORY SYNDROME (SARS)	47	2005
SARS-COV	150	2006
SPIKE PROTEIN	47	2006
NUCLEOCAPSID PROTEIN	38	2006
VIRUS	27	2006
EPIDEMIOLOGY	23	2006
INFECTIOUS BRONCHITIS VIRUS	23	2006
RESPIRATORY VIRUS	9	2007
ADENOVIRUS	9	2007
PORCINE EPIDEMIC DIARRHEA VIRUS	8	2007
HUMAN BOCAVIRUS	7	2007
PCR	7	2007
TGEV	7	2007
GLYCOSYLATION	7	2007

Table 4. Top cited papers during 2004–2007.

Author Name	Year	Publication Journal	Title	GCS
Allander T. et al.	2005	*Proc. Nat. Acad. Sci. USA*	Cloning of a human parvovirus by molecular screening of respiratory tract samples	1034
Li WD et al	2005	*Science*	Bats are natural reservoirs of SARS-like coronaviruses	861
van der Hoek L	2004	*Nat. Med.*	Identification of a new human coronavirus	756
Calisher CH	2006	*Clin. Microbiol. Rev.*	Bats: Important reservoir hosts of emerging viruses	671
Lau SKP et al.	2005	*Proc. Nat. Acad. Sci. USA*	Severe acute respiratory syndrome coronavirus-like virus in Chinese horseshoe bats	654
Woo PCY et al.	2005	*J. Virol.*	Characterization and complete genome sequence of a novel coronavirus, coronavirus HKU1,from patients with pneumonia	653
Chou KC et al.	2004	*Curr. Med. Chem.*	Structural bioinformatics and its impact to biomedical science	634

The term cooccurrence map are shown in Figure 4. Red clusters are researches on hospital case detection. The green cluster is the study of virus structure and replication and interaction after invading the human body. Yellow clusters are for phylogenetic analysis; and blue clusters are the first-body binding domains and immunodeficiency studies in mice. There is a definite high concentration of red cluster (hospital case detection), followed by green (virus structure and replication and interaction).

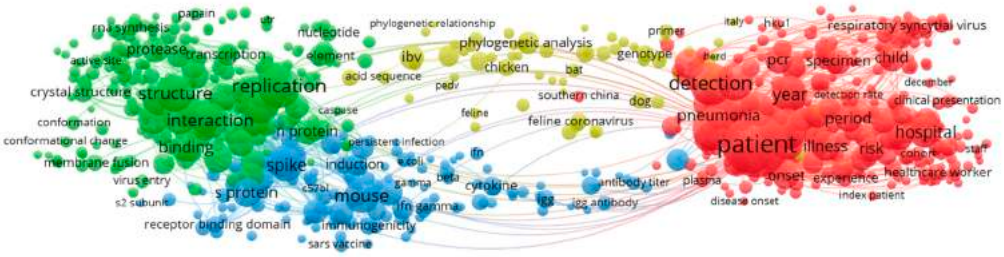

Figure 4. 2004–2007 Term Cooccurrence Map.

4.3. Time Period: 2008–2011

From 2008 to 2011, research on SARS did not decrease, with 332 occurrences and a total of 6961 citations. In addition, "severe acute respiratory syndrome" appeared more than 200 times, with a total of 5000 citations; "bronchitis" appeared 98 times, with a total of 2933 citations; "children" appeared 69 times, and a total of 2933 citations (Figure 5). The topic trends of 2008–2011 are illustrated in Table 5. During 2008–2011, there were four hot papers with over 400 citations, and the information is shown in Table 6.

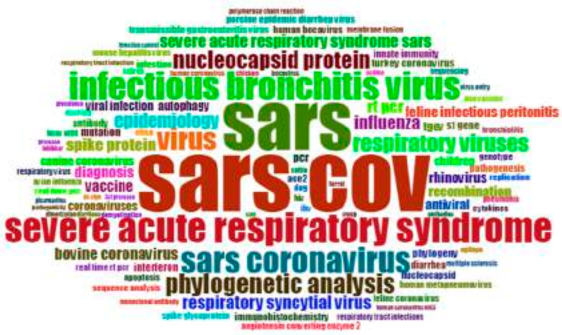

Figure 5. Keywords cloud map of 2008–2011.

Table 5. Items and frequency of hot keywords during 2008–2011.

Item	Frequency	Year
PATHOGENESIS	10	2008
NUCLEOCAPSID	10	2008
APOPTOSIS	9	2008
HUMAN METAPNEUMOVIRUS	9	2008
REPLICATION	9	2008
SARS-COV	87	2009
VIRUS	29	2009
CORONAVIRUS	159	2010
INFECTIOUS BRONCHITIS VIRUS	37	2010
PHYLOGENETIC ANALYSIS	26	2010
INFLUENZA	18	2010
RT-PCR	17	2010
MOUSE HEPATITIS VIRUS	9	2011
PIGS	5	2011
PHYLOGENETIC TREE	5	2011

Table 6. Top cited papers with over 400 citations during 2008–2011.

Author Name	Year	Publication Journal	Title	GCS
Reyes-Turcu, F.E. et al.	2009	*Ann. Rev. Biochem.*	Regulation and Cellular Roles of Ubiquitin Specific Deubiquitinating Enzymes	782
Ernst, B. et al.	2009	*Nat. Rev. Drug Discov.*	From carbohydrate leads to glycomimetic drugs	480
Ruuskanen, O. et al.	2011	*Lancet*	Viral pneumonia	453
White, J.M. et al.	2008	*Crit. Rev. Biochem. Mol. Biol.*	Structures and mechanisms of viral membrane fusion proteins: Multiple variations on a common theme	445

The term cooccurrence map of 2008–2011 publications is generated in Figure 6. The red cluster is the study of protein structure and mechanism, and blue clusters are used to study the immune response to viruses in mice and anchors. Green cluster is the study of diagnosis and treatment of cases and children, and the yellow cluster is a phylogenetic analysis of epidemic dysentery using chickens and dogs. Here, a strong concentration is found in green cluster (diagnosis and treatment of cases and children), followed by red cluster (protein structure and mechanism).

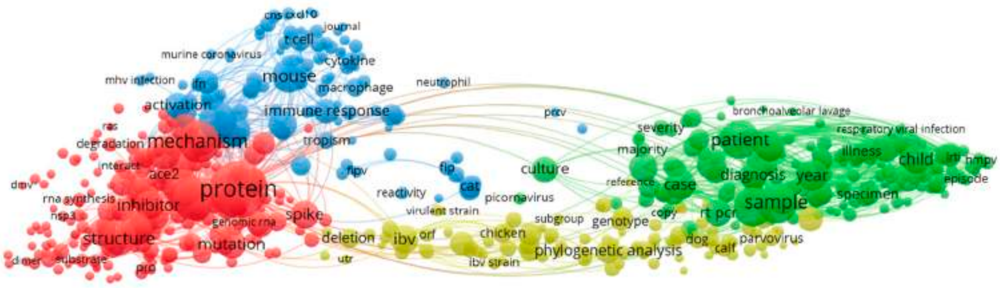

Figure 6. 2008–2011 term co-occurrence map.

4.4. Time Period: 2012–2015

From 2012 to 2015, MERS-COV is the most prevalent topic, with 320 occurrences and cited 13,882 times. "SARS" occurred 161 times and was cited 3359 times. "Infectious bronchitis virus" occurred in 113 papers with 1815 citations (Figure 7). During this period, keywords including "epidemiology", "respiratory viruses", "spike protein", "influenza", "phylogenetic analysis", "vaccine" and "children" are also hot topics, with over 30 occurrences. The trending topics of each year during 2012–2015 are shown in Table 7. During 2012–2015, there are four papers which were cited over 400 times, (Table 8).

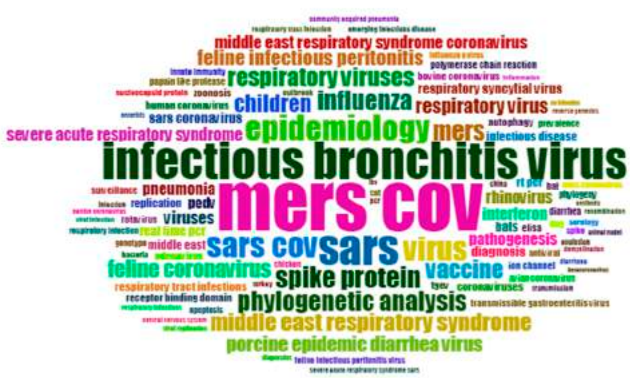

Figure 7. Keywords cloud map of 2012–2015.

Table 7. Items and frequency of hot keywords during 2012–2018.

Item	Frequency	Year
CHINA	10	2012
RESPIRATORY	8	2012
MOLECULAR EPIDEMIOLOGY	8	2012
EPITOPE	7	2012
MOUSE HEPATITIS VIRUS	6	2012
ENCEPHALOMYELITIS	6	2012
SPIKE GLYCOPROTEIN	6	2012
PATHOGENICITY	6	2012
SARS	60	2013
SPIKE PROTEIN	36	2013
PHYLOGENETIC ANALYSIS	34	2013
FELINE CORONAVIRUS	29	2013
RESPIRATORY VIRUS	26	2013
CORONAVIRUS	252	2014
MERS-COV	96	2014
INFECTIOUS BRONCHITIS VIRUS	65	2014
EPIDEMIOLOGY	44	2014
MERS	33	2015
ANTIVIRAL	12	2015
RECOMBINATION	9	2015
RSV	8	2015
BETACORONAVIRUS	8	2015

Table 8. Top cited papers with over 400 citations during 2012–2015.

Author Name	Year	Publication Journal	Title	GCS
Zaki AM et al.	2012	*New Engl. J. Med.*	Isolation of a Novel Coronavirus from a Man with Pneumonia in Saudi Arabia	1308
Assiri A et al.	2013	*New Engl. J. Med.*	Hospital Outbreak of Middle East Respiratory Syndrome Coronavirus	551
Chen Y et al.	2013	*Lancet*	Human infections with the emerging avian influenza A H7N9 virus from wet market poultry: clinical analysis and characterisation of viral genome	546
Raj VS et al.	2013	*Nature*	Dipeptidyl peptidase 4 is a functional receptor for the emerging human coronavirus-EMC	470

The terms extracted from title and abstracts of 2012–2015 publications on coronavirus are used to build the cooccurrence map shown in Figure 8. Red clusters are experiments on mouse proteins and RNA synthesis in mice and blue clusters are phylogenetic analysis of infectious bronchial virus (IBV), porcine epidemic virus (PEDV), cats, dogs, and bats. Green clusters are case studies. It was interesting to note that the green clusters have more concentration, which are on case studies.

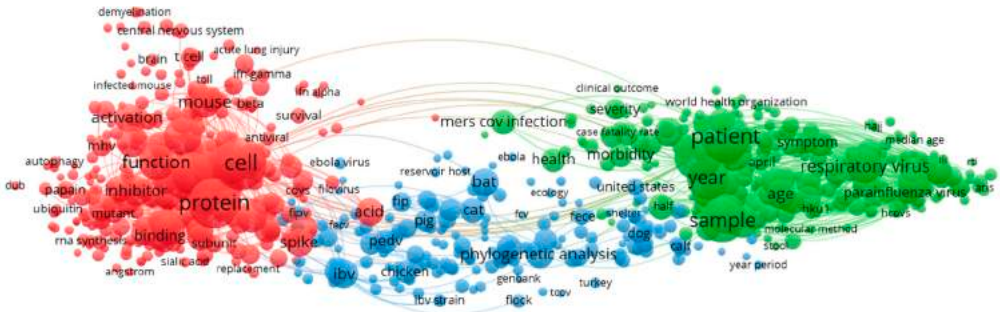

Figure 8. 2012–2015 term co-occurrence map.

4.5. Time Period: 2016–2019

During 2016–2019, it can be seen from Figure 9 that MERS-COV is still the hot issue, occurring 493 times, and cited 4065 times according to the statistical results. "Infectious bronchitis virus" occurred 151 times with 856 citations. "Porcine epidemic diarrhea virus" is also a hot topic in this period, with 74 citations. The most frequent topics during 2016–2019 also included "Saudi Arabia", "epidemiology", "pedv", "SARSCov", "vaccine", "spike protein" and "phylogenetic analysis", with over 35 occurrences, respectively. The trending topics of each year during 2016–2019 are shown in Table 9. There are five papers cited over 110 times during 2016–2019 (refer to Table 10).

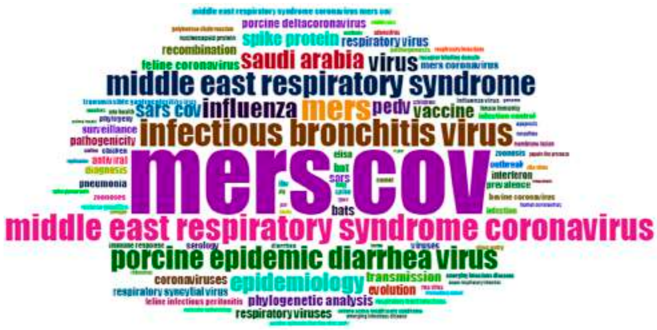

Figure 9. Keywords cloud map of 2016–2019.

Table 9. Items and frequency of hot keywords during 2012–2018.

Item	Frequency	Year
SWINE	14	2016
DOG	11	2016
DIAGNOSTICS	8	2016
RESPIRATORY DISEASE	8	2016
DIVERSITY	6	2016
HUMAN CORONAVIRUSES	6	2016
IMMUNOGENICITY	6	2016
INFECTIOUS BRONCHITIS VIRUS (IBV)	6	2016
MIDDLE EAST RESPIRATORY SYNDROME	78	2017
PORCINE EPIDEMIC DIARRHEA VIRUS	74	2017
SARS-COV	47	2017
VACCINE	47	2017
BATS	32	2017
INFECTIOUS BRONCHITIS VIRUS	87	2018
MERS	84	2018
SAUDI ARABIA	61	2018
VIRUS	60	2018
PEDV	50	2018
FELINE INFECTIOUS PERITONITIS	22	2019

Table 9. *Cont.*

Item	Frequency	Year
ZOONOSIS	21	2019
MOLECULAR EPIDEMIOLOGY	12	2019
RSV	10	2019
3C-LIKE PROTEASE	9	2019
MONOCLONAL ANTIBODY	9	2019

Table 10. Top cited papers with over 100 citations during 2016–2019.

Author Name	Year	Publication Journal	Title	GCS
Thompson BT et al.	2017	*New Engl. J. Med.*	Acute Respiratory Distress Syndrome	168
Warren TK et al.	2016	*Nature*	Therapeutic efficacy of the small molecule GS-5734 against Ebola virus in rhesus monkeys	144
de Wit E et al.	2016	*Nat. Rev. Microbiol.*	SARS and MERS: recent insights into emerging coronaviruses	131
Chan JFW et al.	2016	*J. Infect.*	Zika fever and congenital Zika syndrome: An unexpected emerging arboviral disease	115
Sabir JSM et al.	2016	*Science*	Co-circulation of three camel coronavirus species and recombination of MERS-CoVs in Saudi Arabia	113

The term cooccurrence map of 2016–2019 is shown in Figure 10. The red clusters are studies on the expression and replication of viral enzymes in recipient cells, human immunodeficiency virus, among others. Green clusters are research on patients, hospitals, children and health. Blue clusters are studies of vaccines, virus strains, and the yellow clusters are researches using polymerase chain reaction by animals. Here also, important issue is the increase of green clusters which are on patients, hospitals, children and health.

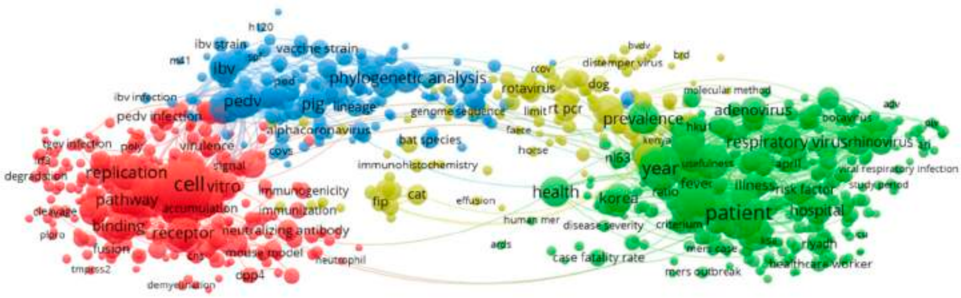

Figure 10. 2016–2019 term co-occurrence map.

4.6. Summary of Research Trends: 2000–2019

From 2000 to 2019, there are two main research hotspots: one is about the structure, expression and interaction of the coronavirus after entering the human body; the other is about the case of patients, including children (Figure 11). Studies on gene expression, interactions and structural changes after the virus invades the human body are mainly focused on the development of antibodies and vaccines, animal experiments, virus mutations and activity changes; Medical research on patients with coronaviruses is mainly focused on patient immune response, diagnosis and treatment.

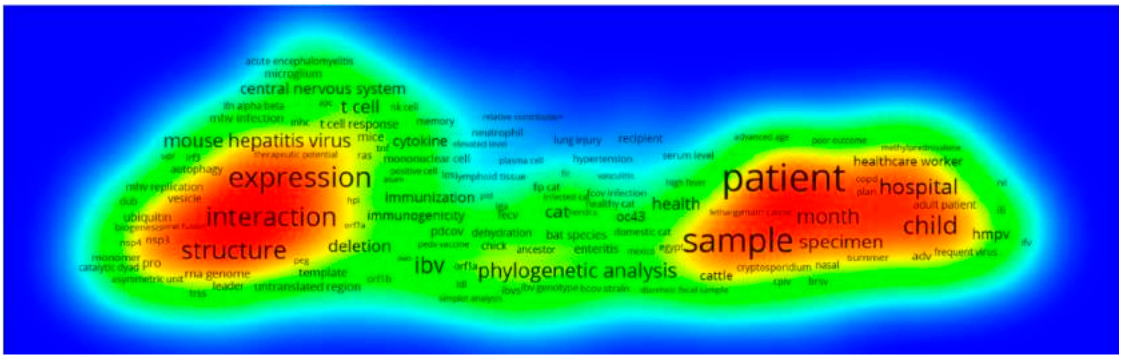

Figure 11. 2000–2019 term co-occurrence density map.

From the time series analysis, it is observed that: public safety incidents affected scientific output and research topics, as observed after SARS and MERS. This may be an obvious increase in terms of focus on research topics. In addition to SARS and MERS, there are a few other types of coronavirus research. Whether these viruses will have a profound impact on humans needs further study. Table 11 shows that in the five time periods, research on patients with coronavirus has been a hot spot, and many scholars have conducted research on patients' symptoms and diagnostic methods, as well as cases of different ages, especially children; In the field of biomedicine, mice are used as test objects, focus on the interaction with cells and virus replication after the virus enters the organism. Spike protein and structural changes of virus, immune reaction, T-cell study as well as antibody development are hot topics after SARS outbreak after 2003. It is worth noting that the study of phylogenetic analysis based on spike protein sequences has become a hot spot in 2012–2019. In the study of coronavirus from 2003 to 2019, in addition to SARS and MERS, IBV, PEDV and mouse hepatitis have also been studied by many scholars.

Table 11. Summary of word cloud and co-occurrence maps for five time series.

Time Period	Top 5 Author Keywords	Top 3 Cluster in Cooccurrence Map
2000–2003	- Coronavirus (168) - Mouse hepatitis virus (137) - Identification (90) - Murine coronavirus (82) - Acute respiratory syndrome (71)	- Red cluster (protein and gene) - Yellow cluster (mouse hepatitis) - Blue cluster (SARS and patient cases study)
2004–2007	- Acute respiratory syndrome (718) - Coronavirus (518) - Identification (477) - SAR Scoronavirus (335) - Virus (322)	- Red cluster (Pneumonia and hospital patient) - Green cluster (virus structure, interaction and replication) - Blue cluster (s protein and mouse study)
2008–2011	- Coronavirus (159) - SARS Cov (88) - SARS (74) - Severe acute respiratory syndrome (39) - Infectious bronchitis virus (37)	- Red cluster (protein structure and interact mechanism) - Green cluster (patient diagnosis and sample) - Blue cluster (immune response and t cell study on mouse)
2012–2015	- Coronavirus (252) - MERS Cov (96) - Infectious bronchitis virus (65) - SARS (60) - Epidemiology (44)	- Red cluster (Cell, protein study test on mouse) - Green cluster (respiratory virus patient study) - Blue cluster (IBV and Phylogenetic analysis of bat, cat and pig)

Table 11. *Cont.*

Time Period	Top 5 Author Keywords	Top 3 Cluster in Cooccurrence Map
2016–2019	- Coronavirus (384) - MERSCov (245) - Infectious bronchitis virus (87) - Porcine epidemic diarrhea virus (74) - Influenza (64)	- Red cluster (Cell replication and neutralizing antibody) - Green cluster (Respiratory virus and patient) - Blue cluster (IBV, PEDV and phylogenetic analysis)

5. Research Trend in 2020

The same methodology was used for 2020 analysis as well. The Web of Science core collection database was used to search SCIE and SSCI papers related to coronavirus published since 2020. The search formula was defined as "TS = Coronavirus" and the language was set to English. The main information of the publication is shown in Table 12.

Table 12. Key information of the 2020 literature search.

Period	2020 January to March
Number of publications	384
Source journals	155
Author keywords	630
Average citations per documents	1.81
Authors of single-authored documents	57
Authors of multi-authored documents	1955
Collaboration Index	6.5

Since the outbreak of the COVID-19 in late 2019, a total of 384 papers have been published. Epidemiological knowledge is adopted to study infection of the virus. Thus, epidemiology and emerging infection diseases become two prominent key words after the names of the virus like 2019ncov, covid19, SARScov2 among others. It is to be emphasized here that in several virology/epidemiology papers, SARS-COV2 refers to the virus which caused the disease, and the disease itself is referred as COVID-19 or 2019cov. In order to analyze the trend of COVID-19 research, Keyword Plus (provided by Web of Science) and author keywords are both adopted to build the trend map (Figure 12) based on the logarithm of keyword occurrences. It should be noted that as keyword plus illustrated, besides acute respiratory syndrome, MERS, replication and expression, a small cluster including pathogenicity, influenza, diarrhea, respiratory syndrome, RIG-I, syncytial virus and crystal-structure shows an aggregate status. Author keywords reveal that studies on virus, pathogenesis, outbreak, travel and porcine delta coronavirus are linked together, and shows a continuing trend. Five papers cited over 40 times are shown in Table 13.

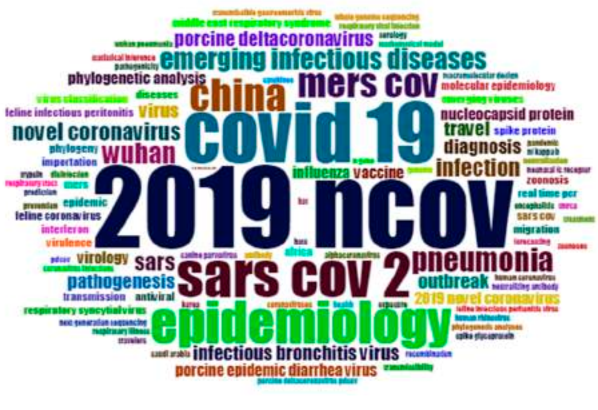

Figure 12. Keywords cloud map of 2020.

Table 13. Top cited papers with over 40 citations of 2020.

Author Name	Year	Publication Journal	Title	GCS
Huang CL et al.	2020	*Lancet*	Clinical features of patients infected with 2019 novel coronavirus in Wuhan, China	97
Zhu N et al.	2020	*New Engl. J. Med.*	A Novel Coronavirus from Patients with Pneumonia in China, 2019	68
Chan JFW et al.	2020	*Lancet*	A familial cluster of pneumonia associated with the 2019 novel coronavirus indicating person-to-person transmission: a study of a family cluster	54
Chen NS et al.	2020	*Lancet*	Epidemiological and clinical characteristics of 99 cases of 2019 novel coronavirus pneumonia in Wuhan, China: a descriptive study	42
Zhou P et al.	2020	*Nature*	A pneumonia outbreak associated with a new coronavirus of probable bat origin	41

Figure 13 shows the term cooccurrence map. Red clusters represent research on proteins and cellular genes. Green clusters represent research on COVID-19 case outbreaks. Yellow clusters represent studies of infection history and symptoms, while blue clusters represent research on respiratory viruses.

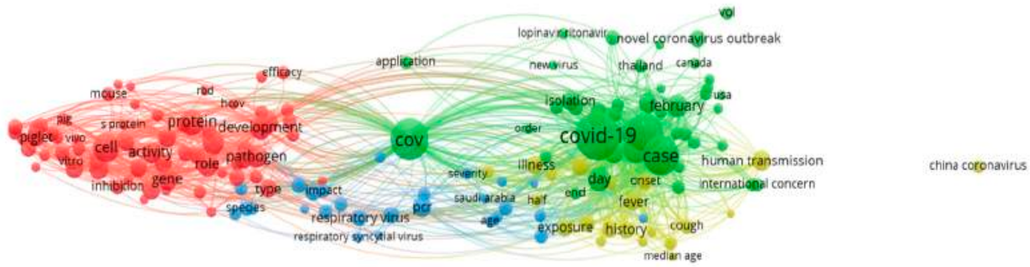

Figure 13. 2020 term co-occurrence map.

As can be seen from the green cluster, the research on COVID-19 has attracted international attention. The author keywords reveal that besides China, other countries include the United States, Canada and Thailand. Fever and cough are the main symptoms of COVID-19, so "fever" and "cough" appear more frequently in the author keywords. In addition, population migration has played a huge role in spreading the virus, so isolation is an effective means to limit the spread of the virus. The terms mouse and pig in the red cluster are receptors of coronavirus and seem to be used for medical tests. Other keywords also include "cell", "protein", "gene" and "pathogen".

From the currently published papers, it is observed that the research on COVID-19 mainly includes epidemiological characteristics, virus traceability studies, early transmission, mode and modeling analysis of COVID-19 predicting the spread and trend of the epidemic, clinical characteristics of COVID-19, diagnosis and treatment also attracted wide attention. The development of antibodies and vaccines will be of great concern. As of 6 May 2020, the number of people infected with COVID-19 has exceeded 3.8 million globally. The global and local economies are highly affected, and socio-economically vulnerable people like daily wedger are at high risk.

6. Discussion and Way Forward

As per [11], experts recognized that an important amount of information is available just three months into the outbreak, there are still concerns about knowledge gaps and lack of clear evidence to support some interventions. The importance of strengthening capacity was highlighted in the research roadmap meeting in February 2020. Integration of research activities in the response to outbreaks and the lessons learnt on SARS, Ebola, Lassa fever, and Nipah have led to a prompt research response now. Participants emphasized that as we mobilize the research community for COVID-19, concerted efforts should be made to facilitate the sustainment of this capacity to support other ongoing or future outbreaks across the world. On the 26th of March, WHO issued six prioritized strategies, to be undertaken by governments to cope with the pandemic. The strategies were as follow: (1) Expand, train and deploy health-care workers; (2) Implement systems to find suspected cases; (3) Ramp up production of tests and increase availability; (4) Identify facilities that can be transformed into coronavirus health centers; (5) Develop plans to quarantine cases; and (6) Refocus governments on suppressing the virus [11]. The document also identified eight knowledge gaps as follows: (1) human animal interface, (2) clinical consideration, (3) vaccine, (4) behavior and education, (5) transmission, (6) therapeutics, (7) healthcare workers, and (8) ethical considerations.

In its analysis, [3] calls for an international protocol of pandemic response, where similar standards are processes are maintained. That needs more research and continued international dialogue. Governance become a key challenge in many countries, and not that much research is conducted on pandemic governance and needs to be considered as a core research gap. In the context of governance the H-EDRM [12], which was described earlier can provide a basic framework. Incorporation of pandemic risk and biological hazards need to be incorporated in the Sendai Framework national implementation in respective countries, which seems to be a gap area. India is one exception, where the National Disaster Management Act (Law) was enacted country wise to respond to COVID-19 for the first time since the promulgation of the law in 2005. Thus, there seems to be a strong gap of incorporation of biological hazards in disaster response, recovery and long-term preparedness. New research is required in the areas of supply chain management, business continuity planning (BCP) and short to medium term response and recovery planning. We also did not notice much research on the risk assessment methodologies, which is an integral part of the disaster response and risk reduction. Multi-disciplinary research incorporating public health, disaster risk reduction, economics of pandemics, social psychology, anthropology, sociology, psychology and ecology are required.

Social innovation in long term care can be seen as the potential option for addressing COVID-10 from the analysis of the Italy case [13]. Social innovation key factors in Italian Long Term Care are listed as follows: (1) coordination/integration in public health care, (2) design to meet target group needs, (3) framework/structural conditions, (4) funding, (5) leadership and governance, (6) local community focus, (7) specificity of LTC, (8) network, (9) sustainability, and (10) workforce. These elements need to be integrated properly to develop new social innovation in long term care. This area needs a strong focus along with development of other innovative and emerging technologies, linked to social innovation.

The International Network of Government Science Advice (INGSA) in its COVID-19 theme has identified sixteen different topics: data visualization/tracking tool, research/education tools, risk communication/preparedness, economics, social resilience/social cohesion, international cooperation/science diplomacy, science communication/trust, national governance, ethics/social science, policy development, role of digital technologies, sub-national governance, global south COVID response, emergencies and mental health, regulation and emergency response, and human rights issues [14].

The key issue emerging from this literature analysis is that over a period of 20 years, different types of epidemic diseases have prompted innovative research on epidemiology, virology, disease infection, vaccine, impacts on different age groups among others. However, an epidemic or pandemic response is not just a health issue, it is very much a disaster response. Thus, basic disaster response framework needs to be adopted and followed. More research is required for new research on biological hazard response, role of different types of technology, governance mechanisms, risk communication, people's behavior and citizen participation. On the public health side, public health preparedness, implementation of H-EDRM frameworks, experience sharing through open access data sharing and publication is required to reduce the north south divide of knowledge management [15]. Research communication, and role of media is another important issue, which is often not properly researched.

As argued in [1], the COVID-19 response as "infodemic", the role of right information through reliable sources and at right time is very important. Infodemic was the term used by WHO to highlight the importance of right and timely information during pandemic. This is the core of risk communication for invisible disasters, where trust on information becomes a core issue. Research on early recovery planning is also urgently required.

As it is said that earthquake problem cannot be solved by seismologist or earthquake engineers, it needs a wider expertise of planner, social scientist, economists among others. Similarly, the pandemic risk reduction and response needs expertise beyond health professionals. In future we hope to see more inter-, trans- and multi-disciplinary approaches in health risk management, pandemic response, disaster risk reduction.

7. Conclusions

Analysis of research papers with keywords "Coronavirus" over last 20 years shows that there has been an increase in the COVID related research after major Coronavirus spread like SARS, MERS etc. Most of the research focus on virology, immunology epidemiology etc., however there is little research on linking biological hazards (including pandemic) to disaster response, covering holistic approach of response. While H-EDRM framework provides an opportunity to the integration of public health and disaster risk reduction, response and recovery, new research needs to focus on different aspects of pandemic response, recovery and long-term development. COVID-19, being an infodemic, information, risk communication, citizen behavior are areas which needs additional research.

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Conflicts of Interest: The authors declare no conflict of interest.

References

1. Hua, J.; Shaw, R. Corona Virus (COVID-19) "Infodemic" and Emerging Issues through a Data Lens: The Case of China. *Int. J. Environ. Res. Public Health* **2020**, *17*, 2309. [CrossRef] [PubMed]
2. Shaw, R.; Kim, Y.K.; Hua, J. Governance, technology and citizen behavior in pandemic: Lessons from COVID-19 in East Asia. *Prog. Disaster Sci.* **2020**. [CrossRef]
3. Djlante, R.; Shaw, R.; DeWit, A. Building resilience against biological hazards and pandemics: COVID-19 and its implications for the Sendai Framework. *Prog. Disaster Sci.* **2020**. [CrossRef]
4. WHO. *COVID 10 Public Health Emergency of International Concern: Global Research and Innovation Forum*; WHO: Geneva, Switzerland, 2020; p. 7.
5. Chan, E.; Shaw, R. Overview of health-EDRM and health issues in DRR: Practices and challenges. In *Public Health and Disasters*; Chan, E., Shaw, R., Eds.; Springer: Singapore, 2020; pp. 1–6.
6. Lo, S.T.T.; Chan, E.Y.Y.; Chan, G.K.W.; Murray, V.; Abrahams, J.; Ardalan, A.; Kayano, R.; Yau, J.C.W. Health Emergency and Disaster Risk Management (Health-EDRM): Developing the Research Field within the Sendai Framework Paradigm. *Int. J. Disaster Risk Sci.* **2017**, *8*, 145–149. [CrossRef]
7. Atenstaedt, R. Word cloud analysis of the BJGP. *Br. J. Gen. Pract.* **2012**. [CrossRef] [PubMed]
8. Garfield, E. Scientography: Mapping the tracks of science. *Current Contents Soc. Behav. Sci.* **1994**, *7*, 5–10.
9. Munoz-Leiva, F.; Viedma-del-Jesusu, M.; Sanchez-Fernandez, J.; Lopez-Herrera, A. An application of co-word analysis and bibliometric maps for detecting the most highlighting themes in the consumer behaviour research from a longitudinal perspective. *Qual. Quant.* **2011**. [CrossRef]
10. Chen, X.; Chen, J.; Wu, D.; Xie, Y.; Li, J. Mapping the research trends by co-word analysis based on keywords from funded project. *Procedia Comput. Sci.* **2016**, *91*, 547–555. [CrossRef]
11. WHO. *A Coordinated Global Research Roadmap: 2019 Novel Coronavirus*; WHO: Geneva, Switzerland, 2020; p. 36.

12. WHO. *Health Emergency and Disaster Risk Management Framework*; WHO: Geneva, Switzerland, 2019.
13. Casanova, G.; Principi, A.; Lamura, G. Social innovation in long-term care: Lessons from the Italian case. *Int. J. Environ. Res. Public Health* **2020**, *17*, 2367. [CrossRef] [PubMed]
14. INGSA. INGSA COVID-19 Resources. 2020. Available online: https://www.ingsa.org/covid/resources/ (accessed on 1 April 2020).
15. CODATA. Data Together COVID-19 Appeal and Action. 2020. Available online: https://codata.org/wp-content/uploads/2020/03/Data-Together-COVID-19-Statement-FINAL.pdf (accessed on 5 April 2020).

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Invited Review

Narrative review of non-pharmaceutical behavioural measures for the prevention of COVID-19 (SARS-CoV-2) based on the Health-EDRM framework

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Abstract

Introduction: Non-pharmaceutical measures to facilitate a response to the COVID-19 pandemic, a disease caused by novel coronavirus SARS-CoV-2, are urgently needed. Using the World Health Organization (WHO) health emergency and disaster risk management (health-EDRM) framework, behavioural measures for droplet-borne communicable diseases and their enabling and limiting factors at various implementation levels were evaluated.

Sources of data: Keyword search was conducted in PubMed, Google Scholar, Embase, Medline, Science Direct, WHO and CDC online publication databases. Using the Oxford Centre for Evidence-Based Medicine review criteria, 10 bottom-up, non-pharmaceutical prevention measures from 104

English-language articles, which published between January 2000 and May 2020, were identified and examined.

Areas of agreement: Evidence-guided behavioural measures against transmission of COVID-19 in global at-risk communities were identified, including regular handwashing, wearing face masks and avoiding crowds and gatherings.

Areas of concern: Strong evidence-based systematic behavioural studies for COVID-19 prevention are lacking.

Growing points: Very limited research publications are available for non-pharmaceutical measures to facilitate pandemic response.

Areas timely for research: Research with strong implementation feasibility that targets resource-poor settings with low baseline health-EDRM capacity is urgently needed.

Key words: health-EDRM, behavioural measures, non-pharmaceutical, primary prevention, droplet-borne, biological hazards, COVID-19, SARS-CoV-2, coronavirus, pandemic

Introduction

Uncertainties in disease epidemiology, treatment and management in biological hazards have often urged policy makers and community health protection agencies to revisit prevention approaches to maximize infection control and protection. The COVID-19 pandemic, a disease caused by novel coronavirus SARS-CoV-2, has pushed global governments and communities to revisit the appropriate non-pharmaceutical health prevention measures in response to this unexpected virus outbreak.[1] The World Health Organization (WHO) health emergency and disaster risk management (health-EDRM) framework refers to the structured analysis and management of health risks brought upon by emergencies and disasters and was developed based on the Sendai Framework for Disaster Risk Reduction 2015–2030. The framework focuses on prevention and risk mitigation through hazard and vulnerability reduction, preparedness, response and recovery measures[2] and further calls attention to the significance of community involvement to counteract the potential negative impacts of hazardous events such as infectious disease outbreaks.[2] While the framework does not provide details on event-specific prevention, it is well justified for primary prevention measures against COVID-19, which is defined as a biological hazard under the health-EDRM disaster classification.[3] While there is evidence for potential COVID-19 droplet transmission,[4] the WHO has suggested that airborne transmission may only be possible in certain circumstances[4] and further evidence is needed to categorize it as an airborne disease specifically.

Health-EDRM prevention measures can be classified into primary, secondary or tertiary levels.[5] Primary prevention mitigates the occurrence of illness through an emphasis on health promotion and education aimed at behavioural modification[6]; secondary prevention involves screening and infection identification; tertiary prevention focuses on treatment. In the context of COVID-19, both secondary and tertiary preventive measures are complicated due to the high incidence of asymptomatic patients,[7] the lack of consensus and availability of specific treatment or vaccine[8] and the added stress on the health system during a pandemic. Primary prevention that focuses on protecting an individual from contracting an infection[9] is therefore the most practical option. A comprehensive disaster management cycle (prevention, mitigation, preparedness, response and recovery) encompasses both top-down and bottom-up measures.[10,11] Top-down measures require well-driven bottom-up initiatives to successfully achieve primary prevention and effectively modify community behaviours.[12] During and since the writing of this review, several landmark publications have studied and addressed the effect of non-pharmaceutical behavioural measures in preventing the transmission of COVID-19, generally concluding that while effectiveness and uptake of measures varied, behavioural change at personal and population levels is key to effectively control the spread of COVID-19.[13–17] The purpose of this narrative review is to highlight the feasibility of implementing non-pharmaceutical preventive measures within a population facing an emergency, building on the health-EDRM framework, and theoretical aspects of behavioural change presented in other publications.

Based on the health-EDRM framework, which emphasizes the impact of context on efficacy of measure practices,[3] this article examines available published evidence on behavioural measures that might be adopted at the personal, household and community levels for droplet-borne transmitted diseases and enabling and limiting factors for each measure. Additionally, this article reviews the strength of available scientific evidence for each of the behavioural changes, which may reduce health risks.

Methodology

A literature search was conducted in May 2020. English language-based literature published between January 2000 and May 2020 were identified and included. Further literature was identified using the references of those already reviewed. Types of literature include international peer-reviewed articles, online reports, commentaries, editorials, electronic books and press releases from universities and research institutions, which include expert opinions. Grey literature published by the WHO, the US Centers for Disease Control and Prevention (CDC) and other local government publications and information outlets were also included. Literature that did not fulfil the criteria was excluded, for example peer-reviewed studies without English-language abstracts.

Research databases examined in this study included PubMed, Google Scholar, Embase, Medline and Science Direct. The keywords and phrases included in the initial search can be broadly categorized into three groups: those relating to the virus, including variations of COVID-19 nomenclature, or relevant to broader respiratory viruses (such as 'COVID-19', 'SARS', 'enveloped viruses'); those relating to general disease prevention and management (such as 'transmission', 'risk management') and those relating to primary prevention measures (such as 'handwashing', 'coughing and sneezing', 'face masks'). The full list can be found in Appendix 1. Behavioural measures as well as risk factors for infectious disease transmission were reviewed in order to generate 10 common preventive measures for discussion. The avoidance of cutlery sharing, for example, was generated after determining it as a highly preventable risk for infectious disease transmission. Each primary prevention measure was summarized narratively according to the risk factors, co-benefits, enabling and limiting factors and strength of evidence. Three reviewers assessed the studies independently and agreed on the final research used.

The literature was categorized according to the Oxford Centre for Evidence-Based Medicine Levels of Evidence (Fig. 1),[18] which systemizes strength of evidence into levels, based on the process of study design and methodology. Three reviewers collectively engaged in and agreed on the final categorization.

No new data were generated or analysed in support of this review.

LEVEL	THERAPY / PREVENTION, AETIOLOGY / HARM
1A	Systematic Review (SR) (with homogeneity) of Randomised Controlled Trials (RCTs)
1B	Individual RCT (with narrow Confidence Interval)
1C	All or none
2A	SR (with homogeneity) of cohort studies
2B	Individual cohort study (including low quality RCT; e.g., <80% follow-up)
2C	"Outcomes" Research; Ecological studies
3A	SR (with homogeneity) of case-control studies
3B	Individual Case-Control Study
4	Case-series (and poor quality cohort and case-control studies)
5	Expert opinion without explicit critical appraisal, or based on physiology, bench research or "first principles"

Fig. 1 The Oxford Centre for Evidence-Based Medicine (OCEBM) Levels of Evidence (adapted from www.cebm.net).[18]

Results

The search identified 104 relevant publications, all of which were reviewed and included in the results analysis. The search identified and grouped 10 common bottom-up, non-pharmaceutical, primary prevention behavioural measures, based on the health-EDRM framework. The review of evidence is disaggregated into the 10 prevention measures.

Six 'personal' protective practices (engage in regular handwashing, wear face mask, avoid touching the face, cover mouth and nose when coughing and sneezing, bring personal utensils when dining out and close toilet cover when flushing), two 'household' practices (disinfect household surfaces and avoid sharing cutlery) and two 'community' practices (avoid crowds and mass gatherings and avoid travel) were identified. Tables 1–3 highlight the potential health risk, desired behavioural changes, potential health co-benefits, enabling and limiting factors and strength of evidence available in published literature with regard to these measures.

Of note, a number of the reviewed articles report an assessment of more than one primary prevention measure. The review results showed that ~68% of the studied literature was associated with personal practices, 13% with household practices and 19% with community practices. The measures of engaging in regular handwashing, wearing face masks as well as avoiding mass gatherings were among the most commonly studied preventive measures. Details of each utilized reference can be found in Appendix 2.

Discussion

Evidence relating to 10 common health-EDRM behavioural measures for primary prevention against droplet-borne biological hazards were identified and reviewed. The information referenced here is based on best available evidence and will need to be updated as new studies and guidelines are published, and the understanding of the scientific community is enhanced. At the time of writing, there is an outstanding question as to whether COVID-19 is transmitted through droplet or aerosol in the community. Following the writing of this review, certain areas of evidence have evolved. On June 5, 2020, the WHO updated its official guidance to recommend that face masks be worn by the general public as a preventive measure against COVID-19 transmission.[122] The WHO had previously recommended that masks be worn only by healthcare workers and people confirmed to have COVID-19, due to limited evidence that masks worn by health individuals may be effective as a prevention measure.[123] The knowledge and consensus within the scientific community on COVID-19 continue to evolve at an unprecedented rate.

Table 1 (Part 1): Personal practices as preventive measure—risk; behavioural change; health co-benefits; enabling and limiting factors and strength of evidence

	Engage in regular handwashing	Wear face mask	Avoid touching the face
Risk	• COVID-19 is transmittable through respiratory fluid droplets[4,19] • Droplets can persist on hands and other surfaces[20] • Droplets may be transferred if hands are not disinfected	• Respiratory droplets from other individuals and hand-to-face contacts can result in droplet intake through the nose and mouth[4,21,22] • Viruses have the potential to survive in the respiratory tract.[23] The virus may also enter through ocular means, although studies focusing specifically on COVID-19 are limited[24] • COVID-19 has an incubation period of as long as 19 days[25]; asymptomatic or mildly symptomatic individuals may spread the virus through coughing or sneezing • In 2010, WHO stated that where there is improper mask usage, risk may increase[26]	• Recent research has suggested that nasal carriage[27] and ocular entry[24] are key alternative routes to oral entry into the respiratory tract for COVID-19 • It has been demonstrated that COVID-19 can be detected on surfaces of plastic, stainless steel, copper and cardboard for up to 72 hours[20] after contamination. Hand-to-face contact following contact of public surfaces may pose a risk
Behavioural change	• Wash hands with soap[25,28–34] for a minimum of 20 seconds using a step-by-step guideline such as the WHO healthcare-based 11-step guideline[35] • Wash hands before eating, after bathroom usage, after mask removal, etc. • Practice alternative handwashing routines as long as they maintain the core principle of ensuring that the entire surface area of the hands is scrubbed[36] • Ensure commonly missed areas are washed, such as the thumbs and fingertips[37–40]	• Wear surgical face masks[25,33,34,41–44] to create a physical barrier preventing the spread or intake of the virus-containing respiratory droplet (which are released by coughing or sneezing) through facial openings[45] • Wear face masks to minimize the touching of the nose and mouth as these can serve as transmission routes for COVID-19[21,46,22,4] • Use face masks correctly to ensure the best overall effectiveness, including one-time usage; limiting usage to 1 day and avoid touching the surface to minimize risk of self-contamination[47,48]	• Avoid touching the face to minimize the risk of COVID-19 contact through the body's main entry points for transmittable conditions[32–34,41,49]: the mouth, the eyes and the nose • Exercise increased awareness of this unwanted practice to minimize the risk of infection, as self-touching of the face may be spontaneous[50,51]

Continued

Table 1 (Part 1) Continued

	Engage in regular handwashing	Wear face mask	Avoid touching the face
Co-benefit(s)	• Prevention of other contact transmissible diseases such as influenza,[52,53] to some extent, diarrhoea[54,55] and eye infections[56] • Potential for reduced infection transmission in community and household[57]	• Protection against other microbes transmitted by respiratory droplets through the nose, mouth or eyes[24,27] • Protection from air pollutants and other air particles,[58,59] which could cause other respiratory conditions[60] such as asthma and lung cancer[61,62]	• Minimizes contracting diseases with similar transmission pathways such as influenza[49,63] • Reduce risk of transferring bacterial pathogens found on hands[64]
Enabling factor(s)	• Availability and affordability of sufficient running water, soap, and alcohol-based rubs	• Access to effective face masks • Information about the correct use of face masks, including proper disposal • Information about when to wear facemasks • Socio-cultural acceptance and habit on wearing face masks (global East vs. West)	• Effectiveness may be limited for infants, children and others who do not have sufficient conscious control of body movement
Limiting factor(s) and/or alternative(s)	• Alcohol-based formulas as an alternative; efficacy in killing enveloped viruses has been demonstrated[65] • Use of ash and mud as an alternative in areas where there is no access to soap or alcohol-based rubs. Although these carry potential antimicrobial properties,[66] their efficacy in counteracting viral infections is not well-evidenced[67] • Sharing and reusing water or water containers, in areas lacking running water, elevate the risk of transmission through droplets.	• For those who cannot access surgical face masks, due to affordability, availability or otherwise, homemade masks[69] accompanied with the same hygienic measures can be considered[70]	• Where face touching is necessary or difficult to control, for example in infants or children, handwashing will be a more effective prevention measure

Continued

Table 1 (Part 1) Continued

	Engage in regular handwashing	Wear face mask	Avoid touching the face
Strength of evidence	• Published evidence showed handwashing is a core community prevention measure for COVID-19 transmission • Handwashing communities display lower risks of developing transmittable diseases when compared to their non-handwashing counterparts, in both rural[66] and urban populations[71] • The measure is recommended by multiple governing bodies, including the WHO[41] and CDC[42] • Studies from Severe Acute Respiratory Syndrome (SARS), although not conclusive, are suggestive of handwashing as an effective measure[72] • 20 seconds may be considered a minimum duration given that time reductions, for example to 5 seconds,[73] have been demonstrated as less effective • Soap and alcohol-based rubs are well evidenced in their capability to interact with and degrade enveloped viruses[43,65] • Evidence of ash or mud-based alternatives as antimicrobials is limited; no concrete evidence with respect to efficacy against COVID-19 or other viral infections was identified	• Multiple extensive studies on the similar SARS coronavirus concluded that there is evidence of effective transmission risk reduction[28–30,74] • Success of Hong Kong and Taiwan's high compliance to mask-wearing practices[75] has been potentially reflected in the low rate of locally infected cases of COVID-19,[76] with both communities having reported periods of no new infections despite initial surges[77] • Used in conjunction with other practices such as social distancing, a model simulation demonstrated community-wide benefits of mask-wearing[78]	• Such measures have been recommended for influenza in the past[31] • There is strong evidence of viral infections entering through the facial entry points and has been demonstrated for COVID-19,[27,24] although evidence for the impact of face touching in disease transmission was not found • The stability of COVID-19 virus on certain surfaces has been evidenced. Similarly, previous studies have demonstrated the stability of other coronaviruses such as SARS, on such surfaces[79]

Continued

Table 1 (Part 2): Personal practice as preventive measure—risk; behavioural change; health co-benefits; enabling and limiting factors; and strength of evidence

	Cover mouth and nose when coughing and sneezing	Bring personal utensils when dining out	Close toilet cover when flushing
Risk	• COVID-19 is transmittable through droplets[19] and has the potential to remain stable on surfaces up to 72 hours.[20] Open coughing, sneezing, and talking may directly or indirectly transmit COVID-19.[49] Research suggests that such pathogen-bearing droplets can travel up to 7–8 m[80]	• There is a high possibility of COVID-19 transmission through saliva droplets[81,82] in instances where public utensils are not sufficiently disinfected[83,84]	• There is growing evidence of COVID-19 being present in stool after clearance through the respiratory tract[85,86] • Virus particles present in stool can be transmitted through toilet plume generated after flushing,[87,88] especially if the toilet is unclosed
Behavioural change	• Cough/sneeze into tissue paper that is disposed immediately • Replace mask after a major sneeze • Cough or sneeze into elbow or shirt if mask or tissue is unavailable[89] • These practices[25,30,34,41–43] minimize droplet landings on the hands, which are most likely to come into contact with oneself and other surfaces. Hands should be disinfected after coughing or sneezing	• Avoid food consumption with public utensils, or utensils that have not been confirmed to be disinfected • Use personal utensils[34,90,91] that have been appropriately disinfected for food consumption	• Cover toilets prior to flushing, both at home and in public • Avoid public toilets during such a pandemic, especially those with toilets lacking lids[92]
Co-benefit(s)	• Minimizing risk of other droplet-transmittable diseases[49]	• Prevention of other diseases that are transmitted through saliva[63]	• Improved household hygiene and protection from pathogens present in stool, such as bacterial or norovirus infections causing gastroenteritis[88]

Continued

Table 1 (Part 2) Continued

	Cover mouth and nose when coughing and sneezing	Bring personal utensils when dining out	Close toilet cover when flushing
Enabling factor(s)	• Access to masks and tissue • Adequate mobility and reaction to raise elbow or tissue to the face	• Access to personal reusable or single-use utensils	• Access to a toilet with a functional lid
Limiting factor(s) and/or alternative(s)	• People with limited mobility, such as the elderly,[93,94] may not be able to react in time. The alternative is to maximize mask wearing as a permanent physical barrier	• May not be applicable to contexts where eating with hands is the tradition. Handwashing should be the primary preventive measure in these contexts • Where personal utensils are not available, single-use utensils can be considered, although there are environmental implications of disposable utensils[95,96]	• Another study has suggested that due to space between the lid and the toilet bowl, shutting the lid may not impede emissions entirely[97] • For households lacking lidded toilets, other protective measures include regular cleaning; wearing a face mask during toilet usage and avoiding sharing toilets
Strength of evidence	• There is strong evidence supporting the transmission of COVID-19 through respiratory droplets, which can be expelled in sneezing and coughing[32,98,99] • Some evidence indicates that wearing a mask redirects coughed particles to a less harmful direction[44]—similar outcome may be inferred for tissue or elbow blockage, although it may not be as effective • There is lacking evidence on how each of the behavioural changes contribute to risk reduction for COVID-19 specifically	• There is no specific evidence of COVID-19 transmitting through public cutlery • Limited evidence suggesting restaurants or caterers fail to properly disinfect their reusable cutlery	• Although this has not been directly confirmed, there is growing evidence that COVID-19 may be present in stool • There is evidence that toilet plumes ascend when toilets remain open • This measure has been suggested by authorities in places such as Hong Kong[33]

Continued

Table 2 Household practices as preventive measure—risk; behavioural change; health co-benefits; enabling and limiting factors and strength of evidence

	Disinfect household surfaces	Avoid sharing utensils
Risk	• COVID-19 has varying stability on different household surfaces, including metal, wood, glass, plastic, paper and steel.[100] • Personal belongings such as mobile phones and laptops have been shown to carry a high load of bacteria[101,102] due to inadequate cleansing and lots of hand contact. The same may apply for virus particles	• Studies have previously demonstrated cutlery sharing practices as a risk for oral transmission[103] • Due to the high possibility of COVID-19 transmission through saliva droplets,[81,82] it may pose similar risk • There is additional unknown risk due to potential for asymptomatic transmission[25]
Behavioural change	• Disinfect households regularly,[29,30,32–34,42] especially frequently touched objects and surfaces,[48] with biocidal agents such as 62–71% ethanol, 0.1% sodium hypochlorite or 0.5% hydrogen peroxide[79] • Use a dilution of 1:50 bleach for general household disinfecting of flooring and doors[79] • Disinfect smaller objects, such as keys, or surfaces that come in contact with the face and mouth, such as mobile phones, with 62–71% ethanol or alcohol wipes instead,[79] due to potential hazards from bleach[104]	• Avoid sharing of utensils or serving food from a communal dish with used utensils • Use designated serving utensils to prevent saliva-based droplet transmission • Maintain hygiene practices, such as adequate cleaning of all utensils
Co-benefit(s)	• Improved general household hygiene, such as mould reduction[105,106] • Opportunity for mild physical activity to compensate for lack of outdoor exercise during COVID-19 social isolation	• Reduced risk of other saliva-transmitted bacteria while utensil sharing[90] • Reduced risk of dental caries transmission[107]
Enabling factor(s)	• Access to proper disinfectants • Knowledge on safe use and storage of disinfectants	• Availability of serving utensils • Cultural appropriateness, such as when seating in settings where such sharing is expected
Limiting factor(s) and/or alternative(s)	• Where resources are limited, households should use the best disinfectant possible, reduce the frequency of disinfection or target frequently touched surfaces such as door handles	• Where appropriate, hand consumption after adequate handwashing may be considered to avoid utensil sharing. Proper handwashing practices must be observed
Strength of evidence	• Studies exist on the effectiveness of various household disinfectants against other viruses, including coronaviruses[79] • Evidence on the effectiveness against COVID-19 specifically is lacking	• Given its transmission through droplets,[19] and persistence in saliva,[81] this prevention measure should be considered good practice • This measure was recommended by the CDC during the 2003 SARS outbreak.[34] • There is no study on the impact of utensil sharing on COVID-19 specifically • Studies have noted potential spread of *H. pylori* via shared chopsticks[91]

Table 3 Community practice as preventive measure—risk; behavioural change; health co-benefits; enabling and limiting factors and strength of evidence

	Avoid crowds and mass gatherings	Avoid travel
Risk	• Crowded areas with unknown people are considered high risk due to risk of droplet transmission and infection through contaminated surfaces • Talking can potentially result in respiratory infectious disease transmission[108] • Possibility of transmission by asymptomatic carriers within a crowd increases risk[109]	• Travelling to areas with confirmed cases will increase an individual's risk of potential exposure to COVID-19 • The stability of the virus on surfaces,[20] the potential prevalence of asymptomatic carriers,[109] the difficulty and lack of distancing,[110] shared toilets and risk of toilet plume[86] and uncertain travel history of others make environments. such as trains and aeroplanes, challenging in terms of protection and high risk in terms of COVID-19 transmission
Behavioural change	• Observe social distancing measures[4,19,25,32–34,42,78,111] • A separation of 1 m is the minimum as recommended by the WHO.[41] Although most droplets may not travel across this distance, novel studies exploring the influence of aerodynamics[112] as well as the potential for sneezes to travel up to 8 m[80] have led to the recommendation that possible distancing should be maintained wherever possible • Avoid congregating and take precaution when in public areas such as parks, cinemas and restaurants. These areas should make face mask wearing mandatory, carry out temperature checks, limit the number of people in attendance and practice distancing of people	• Avoid travelling to areas with confirmed cases, which are of significant risk[25,33,34] • Take all necessary personal protective measures such as wearing of face masks, eye googles, disinfecting immediate area with alcohol-based solution and avoiding food sharing • Implementing (for authorities) appropriate protective measures such as mandatory temperature checks prior to travel and/or upon arrival, reporting the travel and medical history of each traveller and distancing requirements on transport
Co-benefit(s)	• Reduced outdoor pollution due to minimized outdoor human activity.[113,114] Lower exposure to outdoor air pollution, which causes respiratory illnesses such as lung cancer and contributes to mortality[60,115]	• Reduction of cross-border transmission[111] • Improved general hygiene on transport such as trains or aeroplanes • Environmental benefit from reduced air-travel carbon footprint[116]
Enabling factor(s)	• Ability to avoid crowded areas as permissible by population density, occupation, religion or culture	• Ability to make decisions on when or how to travel
Limiting factor(s) and/or alternative(s)	• Crowded areas may not be avoidable due to occupation, religious necessities or otherwise. Where gathering is necessary, individuals should take personal responsibility to wear masks, keep hands clean and maintain maximum distance from others	• Access to facemasks, goggles or alcohol-based solution for personal protection during travel • The necessity of travel, for personal or professional reasons, such as pilots and the cabin crew

Continued

Table 3 Continued

	Avoid crowds and mass gatherings	Avoid travel
Strength of evidence	• Studies on influenza and COVID-19[117] indicate a potential role of mass gathering reduction in limiting transmission,[118] though studies are limited and not yet conclusive • There are also studies on the elevated transmission of other viruses as a result of mass gatherings[119–121]	• The proximity and contact with individuals heighten the evidenced risk of taking in potential respiratory droplets containing COVID-19 from others • There is no clear evidence regarding increased risk from aeroplane travel specifically

Although direct evidence on the efficacy of COVID-19-specific prevention measures is lacking, largely due to the novelty of the disease, five behavioural measures were identified: regular handwashing, wearing face masks, avoiding touching of face, covering during sneezing or coughing and household disinfecting. Five other potential behavioural measures were also identified through logical deductions from potential behavioural risks associated with transmission of diseases similar to COVID-19.[79] Utensil-related practices, in particular, were heavily limited in evidence to support their efficacy against viral infections.

The efficacy and success of the 10 bottom-up behavioural measures reviewed here are subject to specific enabling and limiting determinants, ranging from demographic (e.g. age, gender, education), socio-cultural, economic (e.g. financial accessibility to commodities) and knowledge (e.g. understanding of risk, equipment use). The viability and efficacy of each measure may be limited by determinants and constraints in different contexts. Resource-deprived areas may face constraints and reduced effectiveness of implementation, especially for measures that require preventive commodities such as face masks and household disinfectants. As such, special attention should be given to rural settings, informal settlements and resource-deficit contexts where access to information and resources such as clean water supply are often limited,[124,125] and sanitation facilities are lacking.[126] For hygiene measures, different alternatives should be promoted and their relative scientific merits should be evaluated, such as the use of ash as an alternative to soap for handwashing[67] or the efficacy of handwashing with alcohol sanitizer, which has been demonstrated in previously published studies for H1N1[127] and noroviruses[128] but not yet concretely for COVID-19. Meanwhile, for measures that have no direct alternatives available, it is important for authorities and policymakers to understand the capacity limitations of certain target groups and provide additional support or put in place other preventive measures. In cases where material resources are scarce, the measures of awareness on sneezing and coughing etiquette as well as avoiding hand-to-face contact are the most convenient to adopt as they require little to no commodities. However, it should be well noted that these measures are likely the most challenging in compliance and enforceability, as they rely on the modification of frequent and natural human behaviours whose modifications would require awareness and practice.[50,51] Furthermore, these can be challenging to implement in target groups with less capacity for health literacy and translation of education into practice, such as infants and elderly suffering from dementia. Cultural patterns can be associated with behavioural intentions. In the case of avoiding utensil-sharing during meals, enforcing change may be conflicted with cultural and traditional norms in Asia and certain European communities.[129]

Of the enabling factors documented for each proposed measure, shared enablers can be identified: accessibility and affordability of resources; related knowledge, awareness and understanding of risk; and associated top-down policy facilitation.

Majority of personal and household practices heavily rely on access to resources, such as adequate water and soap supply for regular handwashing, quality face masks and household disinfectants. Various theories of the 'Knowledge, Attitudes, Practices' model have assumed that individual knowledge enhancement will lead to positive behavioural changes.[130] Health measures targeting mask wearing might aim to enhance (i) the individual's risk perception, knowledge and awareness on protection effectiveness of masks, and how to properly wear a mask so that the prevention is most effective; (ii) an individual or community's attitude towards the practice of mask wearing and encouraging compliance in the west, as studies demonstrate a relatively greater social stigmatization towards mask wearing among Westerners than East Asians[131] and (iii) normalizing the practice of habitual mask wearing. Such a conceptual framework should be utilized in the implementation of the health initiatives. In terms of overarching knowledge, health education on symptom identification is also important, as seen on government platforms such as the CDC.[42] Enhancing health-seeking behaviour of potential carriers is critical to promoting a rapid response for quarantine or hospitalization.

At the individual level, behavioural changes have different sustainability potentials and limitations. Measures can also result in unintended consequences. For example, regarding the improper disposal of face masks[132] and the incorrect use of household disinfectants,[133] careful monitoring is critical in order to maximize impact while minimizing further health and safety risks. Top-down policy facilitation and strengthening of infrastructure will be essential for effective implementation. Top-down efforts in resource provision, such as the distribution of quality masks to all citizens by the government or similar authority,[134] enhance personal and household capacities to mitigate infection risks. Regarding compliance, the effectiveness of community practices, such as crowd and travel avoidance, is highly dependent on the needs and circumstances of an individual and a community. More assertive top-down policies such as travel bans and social distancing rules may drive bottom-up initiatives within communities under legal deterrence.[135] However, in order to ensure population-level compliance to recommendations that have wide-ranging socioeconomic impact and involve more than a day-to-day behavioural change, careful risk and information communication is required, which takes into consideration practical, legal and ethical aspects. Research into promoting behavioural change during the COVID-19 pandemic have suggested that public health professionals, policy makers and community leaders can enhance compliance by creating a sense of motivation in individuals rather than creating anxiety that can lead to defensive avoidance.[16] Information should be tailored and account for language, education and health literacy, with input from stakeholders, such as community leaders, religious heads or allied health workers, who can advise on how to enhance understanding of risks and benefits, especially if targeted at marginalized populations.[16,17] It is important to create a bipartisan, shared sense of identity and cooperative responsibility within the population, for example using collective terms such as 'us' or 'we' in risk communication, and using interdisciplinary approaches that bring together groups from different backgrounds, such as medical practitioners, epidemiology experts, community leaders and non-governmental agencies working at the grassroots level.[17]

With regard to the strength of evidence available in the reviewed literature (Table 4), the largest proportion of studies fell into Level 5 (69%) classification, which encompasses a range of study designs and methodologies such as narrative reviews, experimental studies, modelling studies and expert opinions. Less than 1% of the identified resources were classified into 'Others', which includes the WHO Dashboard for latest figures on COVID-19. Level 4 studies, such as cross-sectional studies and case series, contributed a relatively large portion (16%) with many focusing on the disease progression and patterns of specifically identified patients. The low proportion of Level 1 studies (7%) compared to Level 4 or 5 may be attributed to the novelty of

Table 4 Overview of behavioural measures against COVID-19 transmission in the reviewed articles, categorized by the OCEBM Levels of Evidence (See Appendix 2 for details)

Category	Primary preventive measure	Number of referenced articles per OCEBM categorization level											
		1a	1b	1c	2a	2b	2c	3a	3b	4	5	Others	Total
Personal practices	Engage in regular handwashing	4	5	0	0	1	0	2	2	3	17	0	34
	Wear face mask	0	2	0	0	1	0	0	2	7	18	1	31
	Avoid touching the face	0	0	0	0	2	0	0	0	1	10	0	13
	Cover mouth and nose when coughing and sneezing	0	0	0	0	0	0	0	0	2	15	0	17
	Bring personal utensils for when dining out	0	0	0	0	0	0	0	0	2	8	0	10
	Close toilet cover when flushing	0	0	0	0	0	0	0	0	2	6		8
Household practices	Disinfect household surfaces	0	0	0	0	0	0	0	1	1	11	0	13
	Avoid sharing utensils	0	0	0	0	1	0	0	0	4	4	0	9
Community practices	Avoid crowds and mass gatherings	0	0	0	0	0	0	0	0	2	21	0	23
	Avoid travel	0	0	0	0		0	0	0	3	6	0	9
Total		4	7	0	0	5	0	2	5	27	116	1	167*

OCEBM, Oxford Centre for Evidence-Based Medicine.
*Some of the 104 publications are referenced against more than 1 of the 10 primary preventive measures.

COVID-19. Higher level studies generally involve more rigorous and stringent methodologies, which would inevitably require more time.

Regarding individual primary prevention measures, evidence is most lacking at all levels for the practices involving avoidance of utensil sharing (5%), bringing personal utensils (6%), travel avoidance (5%) and the closing of toilet lids when flushing (5%). On the other hand, most of the available evidence supports measures such as handwashing (20%), wearing face masks (19%) and avoiding crowds (14%). Literature relevant to regular handwashing was the strongest in terms of study design, with 26% of the total literature identified for this particular practice being Level 1 studies and 82% of all Level 1 studies identified being associated with regular handwashing. In the case of a novel or emerging disease such as COVID-19, there is limited available evidence that can be related specifically to the disease and pandemic, but some findings are deduced from studies on other similar viral infections and transmittable conditions, such as SARS or Influenza. Many measures proposed by health authorities are not based on rigorous population-based longitudinal studies. While handwashing is well regarded as a core measure by global and national public health agencies such as the WHO[41] and CDC,[42] and the chemical properties of eliminating enveloped viruses is well understood,[43,65] specific studies on the efficacy of practice and impact on COVID-19 transmission are lacking. Due to the uncertainties of disease pathology and epidemiology, effectiveness of behavioural measures against COVID-19 is far from conclusive. Other uncertainties are also reported on virus surface stability[20] and whether the efficacy of disinfectants against surface-stable viruses may vary with COVID-19.[79] Similar deductive evidence approaches from studies on other viruses have been utilized to judge the efficacy of face masks or the closing of toilet lids.[87,88] Although published evidence suggested individual measures such as covering coughs and sneezes to be helpful against droplet transmissions,[19] further research is needed to understand the true efficacy of coverings such as masks, tissues or elbows as an adequate preventive measure against COVID-19.

Given the rapid knowledge advancement and research updates related to COVID-19, further study updates will be warranted to identify the most appropriate behavioural measures to support bottom-up biological hazard responses. Cost-effectiveness of the measures, their impact sustainability, co-benefits and risk implications on other sectors should also be examined and evaluated. Standardized studies across different contexts should be enhanced, for example conducting tests on the efficacy of different disinfectants or soaps under a standardized protocol. Such studies would increase evidence on individual and comparative efficacy of the behavioural measures.

The limitations in this review include language, database inclusion, online accessibility of the article, grey literature and informal publication outlets, and missed keywords. Search terms were determined using variations of terms for COVID-19 or respiratory viruses, as well as a number of preventive practices that are well documented. However, search terms did not encompass the full spectrum of terms relating to behavioural measures. For community practices, the terms searched included 'mass gathering' and 'social isolation' but not 'travel restriction', although limiting travel was later identified as a standalone measure through reviewing the literature search results. Publications documenting the experiences of traditional, non-English-speaking, rural communities during the COVID-19 pandemic may not have been identified in this review. Further research should review the efficacy of various measures in different contexts and make comparisons with their alternative measures. Specifically, alternative preventive measures that can be practiced in resource-poor, developing communities, whose health systems and economies generally suffer the greatest impact during pandemics, are urgently needed. Increased understanding of how to effectively mitigate against biological hazards such as COVID-19 in various contexts will help communities prepare for future outbreaks and build disaster resilience in line with the recommendations from the health-EDRM framework.

Despite the constraints, this review has nevertheless identified common, relevant behavioural measures supported by best available evidence for the design and implementation of health policies that prevent droplet-borne biological hazards. Many of the measures recommended by authorities during the pandemic are based on best practice available rather than best available evidence. The possibility of conducting large cohort or randomized controlled studies is often complicated, and rather infeasible during a pandemic, as noted for face masks.[136,137] Further studies are needed to understand the efficacy of frequently proposed measures for transmission risk reduction. Nonetheless, each of the measures identified has scientific basis in mitigating the risk of droplet transmission,[19] either through personal measures such as handwashing or community-based measures that aim to reduce person-to-person contact. The 10 measures identified in this review constitute only a portion of those non-pharmaceutical and primary preventive behaviours that can mitigate against the transmission of a droplet-borne disease and do not represent the entire spectrum of either non-pharmaceutical or primary prevention measures. Alternatively, the measures identified here can also fall into other subsets such as 'biological hazard prevention' or 'community outbreak prevention'. It is important to explore the efficacy of alternatives, notably for transmission prevention and risk communication in low-resource or developing contexts where the capacity of the health system to mitigate and manage outbreaks is weak. For example, while face masks are understudied, the scientific study of cloth masks as an alternative is severely limited,[70] although recommended by the CDC.[138] Such alternative studies should expand to consider different cultures and contexts where different varieties of disinfectants, face masks and utensils may be used. There is also potential for comparative effectiveness studies to explore measures that provide the greatest transmission risk reduction at the lowest transaction cost to the individual and community and should thus be prioritized in low-resource contexts.[139]

Conclusion

During the outbreak of a novel transmittable disease such as COVID-19, primary prevention is the strongest and most effective line of defence to reduce health risks when there is an absence of an effective treatment or vaccine. COVID-19 is and will be subjected to ongoing research and scrutiny by global scientists, health professionals and policy makers. While research gaps remain on the efficacy of various health-EDRM prevention measures in risk reduction and transmission control of COVID-19, suboptimal scientific evidence does not negate the potential benefits arising from good hygiene practices, especially where the likelihood for negative outcome is minimal. Despite the lack of rigorous scientific evidence, the best available practice-based health education content, effective means of information dissemination, equitable access to resources and monitoring of unintended consequences of the promoted measures, such as environmental pollution due to poor waste management, will be essential. A top-down approach should be multi-sectorial, bringing in policy makers with clinical, public health, environmental and community management expertise to develop a coordinated and comprehensive approach in this globalized world.

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Conflict of interest statement

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References

1. Singer DRJ. Health policy and technology challenges in responding to the COVID-19 pandemic. *Heal Policy Technol* 2020;9:123–5.
2. World Health Organisation. Emergency risk management for health - overview. *Emerg Risk Manag Health Fact Sheets* 2013;1–6.
3. WHO. Health emergency and disaster risk management: overview. *Health Emergency and Disaster Risk Management Fact Sheets*. 2019. Accessed May 17, 2020 . https://www.who.int/hac/techguidance/preparedness/health-emergency-and-disaster-risk-management-framework-eng.pdf?ua=1.
4. WHO. Modes of transmission of virus causing COVID-19: implications for IPC precaution recommendations. *Sci Br* 2020;1–3.
5. Chan EYY, Shaw R. *Public Health and Disasters: Health Emergency and Disaster Risk Management in Asia*, Vol. 343. Tokyo: Springer Singapore, 2020
6. Boslaugh S. *Encyclopedia of Epidemiology*. Thousand Oaks; SAGE Publications, Inc; 2012. doi:10.4135/9781412953948
7. Zhang J, Wu S, Xu L. Asymptomatic carriers of COVID-19 as a concern for disease prevention and control: more testing, more follow-up. *Biosci Trends* 2020;14:206–8.
8. Cascella M, Rajnik M, Cuomo A *et al. Features, Evaluation and Treatment Coronavirus (COVID-19)*. Treasure Island; StatPearls Publishing; 2020.

9. WHO. *Health promotion and disease prevention through population-based interventions, including action to address social determinants and health inequity*. World Health Organization, 2013. Accessed May 17, 2020
10. Chan EYY. *Public Health Humanitarian Responses to Natural Disasters*. London; Routledge; 2017. doi:10.4324/9781315667218
11. Wisner B, Adams J. 15 . Health promotion and community participation. In: Wisner B, Adams J, eds. *Environmental Health in Emergencies and Disasters: A Practical Guide*. Geneva: World Health Organization; 2003. https://apps.who.int/iris/handle/10665/42561%0A
12. Laaser U, Dorey S, Nurse J. A plea for global health action bottom-up. *Front Public Heal* 2016;4:1–5.
13. Pan A, Liu L, Wang C *et al.* Association of Public Health Interventions with the epidemiology of the COVID-19 outbreak in Wuhan, China. *JAMA -J Am Med Assoc* 2020;323:1915–23.
14. Lai S, Ruktanonchai NW, Zhou L *et al.* Effect of non-pharmaceutical interventions to contain COVID-19 in China. *Nature* 2020;1–20.
15. Kong Q, Jin H, Sun Z *et al.* Non-pharmaceutical intervention strategies for outbreak of COVID-19 in Hangzhou, China. *Public Health* 2020;182: 185–6.
16. West R, Michie S, Rubin GJ *et al*. Applying principles of behaviour change to reduce SARS-CoV-2 transmission. *Nat Hum Behav* 2020;4:451–9.
17. Bavel JJV, Baicker K, Boggio PS *et al.* Using social and behavioural science to support COVID-19 pandemic response. *Nat Hum Behav* 2020;4:460–71.
18. OCEBM Levels of Evidence Working Group. "*The Oxford 2009 Levels of Evidence*". Oxford Center for Evidence-Based Medicine. 2009. Accessed May 17, 2020. https://www.cebm.net/2009/06/oxford-centre-evidence-based-medicine-levels-evidence-march-2009/
19. Huang H, Fan C, Li M *et al.* COVID-19: a call for physical scientists and engineers. *ACS Nano* 2020;14: 3747–54.
20. van Doremalen N, Bushmaker T, Morris DH *et al.* Aerosol and surface stability of SARS-CoV-2 as compared with SARS-CoV-1. *N Engl J Med* 2020;382:1564–7.
21. Liu J, Liao X, Qian S, *et al.* Community transmission of severe acute respiratory syndrome coronavirus 2, Shenzhen, China, 2020. *Emerg Infect Dis* 2020;26:1320–1323.
22. Chan JFW, Yuan S, Kok KH, *et al.* A familial cluster of pneumonia associated with the 2019 novel coronavirus indicating person-to-person transmission: a study of a family cluster. *Lancet* 2020;395:514–23.
23. Hui KPY, Chan LLY, Kuok DIT, *et al.* Tropism and innate host responses of influenza a/H5N6 virus: an analysis of ex vivo and in vitro cultures of the human respiratory tract. *Eur Respir J* 2017;49: 1–13.
24. Wei LC, Fen LX, Fang JZ. 2019-nCoV transmission through the ocular surface must not be ignored. *Lancet* 2020;395:e39. doi:10.1016/S0140-6736(20)30313-5
25. Bai Y, Yao L, Wei T, *et al.* Presumed asymptomatic carrier transmission of COVID-19. *JAMA - J Am Med Assoc*. 2020;323:1406–7.
26. World Health Organization. What can I do. *Emergencies preparedness, response*. 2010. https://www.who.int/csr/disease/swineflu/frequently_asked_questions/what/en/ 17 May 2020, date last accessed.
27. Sungnak W, Huang N, Bécavin C, *et al.* SARS-CoV-2 entry factors are highly expressed in nasal epithelial cells together with innate immune genes. *Nat Med* 2020;26:681–7.
28. Lange JH. Use of disposable face masks for public health protection against SARS. *J Epidemiol Community Health* 2004;58:434.
29. Lau JTF, Tsui H, Lau M *et al*. SARS transmission, risk factors, and prevention in Hong Kong. *Emerg Infect Dis* 2004;10:587–92.
30. Lo JYC, Tsang THF, Leung YH *et al.* Respiratory infections during SARS outbreak, Hong Kong, 2003. *Emerg Infect Dis* 2005;11:1738–41.
31. Macias AE, de la Torre A, Moreno-Espinosa S *et al.* Controlling the novel a (H1N1) influenza virus: don't touch your face! *J Hosp Infect* 2009;73:280–1.
32. Desai AN, Patel P. Stopping the spread of COVID-19. *JAMA - J Am Med Assoc* 2020;323:1516. doi: 10.1001/jama.2020.4269
33. Centre for Health Protection. Prevention of coronavirus disease 2019 (COVID-19). *Health Information - Communicable Diseases*. 2020. Accessed May 17, 2020. https://www.chp.gov.hk/files/pdf/prevention_of_covid_19_en.pdf.
34. CDC. Fact sheet for SARS patients and their close contact. 2004. Accessed May 17, 2020. https://www.cdc.gov/sars/about/fs-closecontact.pdf
35. World Health Organization. *WHO Guidelines On Hand Hygiene in Health Care*. Geneva: World Health Organization, 2009
36. Tschudin-Sutter S, Sepulcri D, Dangel M *et al.* Simplifying the World Health Organization protocol: 3 steps versus 6 steps for performance of hand hygiene

in a cluster-randomized trial. *Clin Infect Dis* 2019;69: 614–20.
37. Wong JSW, Lee JKF. The common missed Handwashing instances and areas after 15 years of hand-hygiene education. *J Environ Public Health* 2019;2019:1–7.
38. Freeman MC, Stocks ME, Cumming O, *et al.* Hygiene and health: systematic review of handwashing practices worldwide and update of health effects. *Trop Med Int Heal* 2014;19: 906–16.
39. Arias AV, Garcell HG, Ochoa YR *et al*. Assessment of hand hygiene techniques using the World Health Organization's six steps. *J Infect Public Health* 2016;9: 366–9.
40. Ataee RA, Ataee MH, Mehrabi Tavana A *et al*. Bacteriological aspects of hand washing: a key for health promotion and infections control. *Int J Prev Med* 2017;8:16. doi: 10.4103/2008-7802.201923.
41. World Health Organization. Coronavirus disease (COVID-19) advice for the public. 2020. Accessed May 17, 2020. https://www.who.int/emergencies/diseases/novel-coronavirus-2019/advice-for-public
42. CDC. How to protect yourself and others. *CDC*. 2020. Accessed May 17, 2020. https://www.cdc.gov/coronavirus/2019-ncov/prevent-getting-sick/prevention.html
43. Lotfinejad N, Peters A, Pittet D. Hand hygiene and the novel coronavirus pandemic: the role of healthcare workers. *J Hosp Infect* 2020;105:776–7.
44. Tang JW, Liebner TJ, Craven BA *et al*. A Schlieren optical study of the human cough with and without wearing masks for aerosol infection control. *J R Soc Interface* 2009;6:s727–36.
45. Leung NHL, Chu DKW, Shiu EYC, *et al.* Respiratory virus shedding in exhaled breath and efficacy of face masks. *Nat Med* 2020;26:676–80.
46. Li Q, Guan X, Wu P, *et al.* Early transmission dynamics in Wuhan, China, of novel coronavirus-infected pneumonia. *N Engl J Med* 2020;382:1199–207.
47. Chughtai AA, Stelzer-Braid S, Rawlinson W, *et al.* Contamination by respiratory viruses on outer surface of medical masks used by hospital healthcare workers. *BMC Infect Dis* 2019;19:491. doi:10.1186/s12879-019-4109-x
48. Chin AWH, Chu JTS, Perera MRA, *et al.* Stability of SARS-CoV-2 in different environmental conditions. *The Lancet Microbe* 2020;1:e10. doi:10.1016/s2666-5247(20)30003-3
49. Drexler M, Institute of Medicine (US). *How Infection Works*. Washington (DC): National Academies Press (US); 2010. doi:10.17226/13006
50. Kwok YLA, Gralton J, McLaws ML. Face touching: a frequent habit that has implications for hand hygiene. *Am J Infect Control* 2015;43:112–4.
51. Mueller SM, Martin S, Grunwald M. Self-touch: contact durations and point of touch of spontaneous facial self-touches differ depending on cognitive and emotional load. *PLoS One* 2019;14:1–21.
52. Liu M, Ou J, Zhang L, *et al.* Protective effect of handwashing and good hygienic habits against seasonal influenza: a case-control study. *Med (United States)* 2016;95:1–7.
53. Wong VWY, Cowling BJ, Aiello AE. Hand hygiene and risk of influenza virus infections in the community: a systematic review and meta-analysis. *Epidemiol Infect* 2014;142:922–32.
54. Curtis V, Cairncross S. Effect of washing hands with soap on diarrhoea risk in the community: a systematic review. *Lancet Infect Dis* 2003;3:275–81.
55. Ejemot-Nwadiaro RI, Ehiri JE, Arikpo D, Meremikwu MM, Critchley JA. Hand washing promotion for preventing diarrhoea. *Cochrane Database Syst Rev* 2015;2015:1–81.
56. Stevens S. Reducing the risk of infection: hand washing technique. *Community Eye Heal J* 2008;21:17.
57. Bloomfield SF, Aiello AE, Cookson B, O'Boyle C, Larson EL. The effectiveness of hand hygiene procedures in reducing the risks of infections in home and community settings including handwashing and alcohol-based hand sanitizers. *Am J Infect Control* 2007;35:s27-s64.
58. Pacitto A, Amato F, Salmatonidis A *et al.* Effectiveness of commercial face masks to reduce personal PM exposure. *Sci Total Environ* 2019;650:1582–90.
59. Hansstein FV, Echegaray F. Exploring motivations behind pollution-mask use in a sample of young adults in urban China. *Global Health* 2018;14:1–10.
60. World Health Organization. *WHO | Air pollution*. World Health Organization. 2019. Accessed May 17, 2020. https://www.who.int/health-topics/air-pollution#tab=tab_1
61. Zhang W, Qian CN, Zeng YX. Air pollution: a smoking gun for cancer. *Chin J Cancer* 2014;33:173–5.
62. Rumana HS, Sharma RC, Beniwal V *et al*. A retrospective approach to assess human health risks associated with growing air pollution in urbanized area of Thar Desert, western Rajasthan, India. *J Environ Heal Sci Eng* 2014;12:1–9.
63. Corstjens PLAM, Abrams WR, Malamud D. Saliva and viral infections. *Periodontol 2000* 2016;70:93–110.
64. Vishwanath R, Selvabai AP, Shanmugam P. Detection of bacterial pathogens in the hands of rural school

children across different age groups and emphasizing the importance of hand wash. *J Prev Med Hyg* 2019;60:e103-e108.

65. Siddharta A, Pfaender S, Vielle NJ, *et al.* Virucidal activity of world health organization-recommended formulations against enveloped viruses, including zika, ebola, and emerging coronaviruses. *J Infect Dis* 2017;215:902–6.
66. Luby SP, Agboatwalla M, Feikin DR, *et al.* Effect of handwashing on child health: a randomised controlled trial. *Lancet* 2005;366:225–33.
67. Paludan-Müller AS, Boesen K, Klerings I *et al.* Hand cleaning with ash for reducing the spread of viral and bacterial infections: a rapid review. *Cochrane Database Syst Rev* 2020;4:1–53.
68. Ogunsola FT, Adesiji YO. Comparison of four methods of hand washing in situations of inadequate water supply. *West Afr J Med* 2008;27:24–8.
69. Davies A, Thompson KA, Giri K, Kafatos G, Walker J, Bennett A. Testing the efficacy of homemade masks: would they protect in an influenza pandemic? *Disaster Med Public Health Prep* 2013;7:413–8.
70. Konda A, Prakash A, Moss GA *et al.* Aerosol filtration efficiency of common fabrics used in respiratory cloth masks. *ACS Nano* 2020;14:6339–47.
71. Hadaway A. Handwashing: clean hands save lives. *J Consum Health Internet* 2020;24:43–9.
72. Fung ICH, Cairncross S. Effectiveness of handwashing in preventing SARS: a review. *Trop Med Int Heal* 2006;11:1749–58.
73. Jensen D. Efficacy of Handwashing Duration and Drying Methods. In: *2012 Annual Meeting. Rhode Island; US. International Association for Food Protection*; Iowa: US; 2012.
74. Wu J, Xu F, Zhou W, *et al.* Risk factors for SARS among persons without known contact with SARS patients, Beijing, China. *Emerg Infect Dis* 2004;10:210–6.
75. Leung CC, Lam TH, Cheng KK. Mass masking in the COVID-19 epidemic: people need guidance. *Lancet* 2020;315:945. doi: 10.1016/S0140-6736(20)30520-1
76. Cheng VCC, Wong S-C, Chuang VWM, *et al.* The role of community-wide wearing of face mask for control of coronavirus disease 2019 (COVID-19) epidemic due to SARS-CoV-2. *J Infect* 2020;81:107–14.
77. World Health Organization. WHO coronavirus disease (COVID-19) dashboard. 2020. Accessed May 17, 2020. https://covid19.who.int/explorer
78. Eikenberry SE, Mancuso M, Iboi E *et al.* To mask or not to mask: Modeling the potential for face mask use by the general public to curtail the COVID-19 pandemic. *Infect Dis Model* 2020;5:293–308.
79. Kampf G, Todt D, Pfaender S *et al.* Persistence of coronaviruses on inanimate surfaces and their inactivation with biocidal agents. *J Hosp Infect* 2020;104:246–51.
80. Bourouiba L. Turbulent gas clouds and respiratory pathogen emissions: potential implications for reducing transmission of COVID-19. *JAMA - J Am Med Assoc* 2020;323:1837–8.
81. Khurshid Z, Asiri FYI, Al Wadaani H. Human saliva: non-invasive fluid for detecting novel coronavirus (2019-nCoV). *Int J Environ Res Public Health* 2020;17:2225. doi:10.3390/ijerph17072225
82. To KKW, Tsang OTY, Chik-Yan Yip C, *et al.* Consistent detection of 2019 novel coronavirus in saliva. *Clin Infect Dis* 2020;71:841–3.
83. Coelho AÍM, Milagres RCRM, Martins J de FL *et al.* Microbiological contamination of environments and surfaces at commercial restaurants. *Cienc e Saude Coletiva* 2010;15:1597–606.
84. Mendes RA, Coelho AÍM, de Azeredo RMC. Contamination by Bacillus cereus on equipment and utensil surfaces in a food and nutrition service unit. *Cienc e Saude Coletiva* 2011;16:3933–8.
85. Zhang T, Cui X, Zhao X, *et al.* Detectable SARS-CoV-2 viral RNA in feces of three children during recovery period of COVID-19 pneumonia. *J Med Virol* 2020;92:909–14.
86. Chinese University of Hong Kong. CUHK finds that the coronavirus can persist in stool after its clearance in respiratory tract will conduct stool test for people in quarantine camps for early identification. 2020. https://www.med.cuhk.edu.hk/press-releases/cuhk-finds-that-the-coronavirus-can-persist-in-stool-after-its-clearance-in-respiratory-tract-will-conduct-stool-test-for-people-in-quarantine-camps-for-early-identification (17 May 2020, date last accessed).
87. Barker J, Jones M V. The potential spread of infection caused by aerosol contamination of surfaces after flushing a domestic toilet. *J Appl Microbiol* 2005;99:339–47.
88. Johnson DL, Mead KR, Lynch RA *et al.* Lifting the lid on toilet plume aerosol: a literature review with suggestions for future research. *Am J Infect Control* 2013;41:254–8.
89. Chavis S, Ganesh N. Respiratory hygiene and cough etiquette. *Infect Control Dent Off* 2019;18:91–103.

90. Purohit C. Bacterial transfer from mouth to different utensils and from utensils to food. *Environ Heal East Africa* 2009.
91. Brown LM. Helicobacter pylori: epidemiology and routes of transmission. *Epidemiol Rev* 2000;22: 283–97.
92. Best EL, Sandoe JAT, Wilcox MH. Potential for aerosolization of Clostridium difficile after flushing toilets: the role of toilet lids in reducing environmental contamination risk. *J Hosp Infect* 2012;80: 1–5.
93. Manini TM. Mobility decline in old age: a time to intervene. *Exerc Sport Sci Rev* 2013;41:2. doi:10.1097/JES.0b013e318279fdc5
94. Ferrucci L, Cooper R, Shardell M *et al*. Age-related change in mobility: perspectives from life course epidemiology and geroscience. *Journals Gerontol - Ser A Biol Sci Med Sci* 2016;71:1184–94.
95. Jambeck JR, Geyer R, Wilcox C, *et al*. Plastic waste inputs from land into the ocean. *Science (80-)* 2015;347:768–71.
96. Cheung LTO, Lui CY, Fok L. Microplastic contamination of wild and captive flathead grey mullet (Mugil cephalus). *Int J Environ Res Public Health* 2018;15:597. doi:10.3390/ijerph15040597
97. City University of Hong Kong. CityU experts: aerosol droplets from toilet flushing can rise up to one metre covering toilet lid may not completely eliminate disease transmission toilet bowl must be regularly cleaned. 2020. https://www.cityu.edu.hk/media/press-release/2020/02/13/cityu-experts-aerosol-droplets-toilet-flushing-can-rise-one-metre-covering-toilet-lid-may-not-completely-eliminate-disease-transmission-toilet-bowl-must-be-regularly-cleaned (17 May 2020, date last accessed).
98. Asadi S, Bouvier N, Wexler AS *et al*. The coronavirus pandemic and aerosols: does COVID-19 transmit via expiratory particles? *Aerosol Sci Tech* 2020;2020:1–4.
99. Ong SWX, Tan YK, Chia PY, *et al*. Air, surface environmental, and personal protective equipment contamination by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) from a symptomatic patient. *JAMA - J Am Med Assoc*. 2020;323:1610–2.
100. Fathizadeh H, Maroufi P, Momen-Heravi M, *et al*. Protection and disinfection policies against SARS-CoV-2 (COVID-19). *Le Infez Med* 2020;28:185–91.
101. Rozario S, Rahman H, Fakhruddin AM *et al*. Prevalence of multidrug-resistant bacteria on mobile phone surface. *J Microsc Ultrastruct* 2020;8: 14–19.
102. Koscova J, Hurnikova Z, Pistl J. Degree of bacterial contamination of mobile phone and computer keyboard surfaces and efficacy of disinfection with chlorhexidine digluconate and triclosan to its reduction. *Int J Environ Res Public Health* 2018;15:2238. doi:10.3390/ijerph15102238
103. Crabtree KL, Wojcicki JM, Minhas V *et al*. Association of Household Food- and Drink-Sharing Practices with human Herpesvirus 8 Seroconversion in a cohort of Zambian children. *J Infect Dis* 2017;216:842–9.
104. Slaughter RJ, Watts M, Vale JA, Grieve JR, Schep LJ. The clinical toxicology of sodium hypochlorite. *Clin Toxicol* 2019;57:303–11.
105. Reynolds KA, Boone S, Bright KR, Gerba CP. Occurrence of household mold and efficacy of sodium hypochlorite disinfectant. *J Occup Environ Hyg* 2012;9:663–9.
106. Reynolds KA. Efficacy of sodium hypochlorite disinfectant on the viability and allergenic properties of household mold. *J Allergy Clin Immunol* 2004;113:s180. doi:10.1016/j.jaci.2004.01.082
107. Damle SG, Yadav R, Garg S, *et al*. Transmission of mutans streptococci in mother-child pairs. *Indian J Med Res* 2016;144:264–70.
108. Asadi S, Wexler AS, Cappa CD, Barreda S, Bouvier NM, Ristenpart WD. Aerosol emission and superemission during human speech increase with voice loudness. *Sci Rep* 2019;9:1–10.
109. Yu X, Yang R. COVID-19 transmission through asymptomatic carriers is a challenge to containment. *Influenza Other Respi Viruses* 2020;14:474–5.
110. Lei H, Li Y, Xiao S, *et al*. Routes of transmission of influenza a H1N1, SARS CoV, and norovirus in air cabin: comparative analyses. *Indoor Air* 2018;28: 394–403.
111. Kwok KO, Wong VWY, Wei WI *et al*. Epidemiological characteristics of the first 53 laboratory-confirmed cases of COVID-19 epidemic in Hong Kong, 13 February 2020. *Eurosurveillance*. 2020;25:2000155. doi:10.2807/1560-7917.es.2020.25.16.2000155
112. Blocken B, Malizia F, van Druenen T *et al* Towards aerodynamically equivalent COVID19 1.5 m social distancing for walking and running. 2020. Available at: http://www.urbanphysics.net/Social%20Distancing%20v20_White_Paper.pdf
113. Venter ZS, Aunan K, Chowdhury S *et al*. COVID-19 lockdowns cause global air pollution declines with implications for public health risk. *medRxiv* 2020. doi: 10.1101/2020.04.10.20060673.

114. Dutheil F, Baker JS, Navel V. COVID-19 as a factor influencing air pollution? *Environ Pollut* 2020;263:114466. doi: 10.1016/j.envpol.2020.114466.
115. Kelly FJ, Fussell JC. Air pollution and public health: emerging hazards and improved understanding of risk. *Environ Geochem Health* 2015;37:631–49.
116. Nathans J, Sterling P. How scientists can reduce their carbon footprint. *Elife* 2016;5:e15928. doi: 10.7554/eLife.15928.
117. Nuana D, Brassey J. *What is the evidence for mass gatherings during global pandemics?* Oxford Covid-19 Evidence Service. 2020. Accessed May 17, 2020. https://www.cebm.net/covid-19/what-is-the-evidence-for-mass-gatherings-during-global-pandemics/
118. Ishola DA, Phin N. Could influenza transmission be reduced by restricting mass gatherings? Towards an evidence-based policy framework. *J Epidemiol Glob Health* 2011;1:33–60.
119. Memish ZA, Steffen R, White P, *et al.* Mass gatherings medicine: public health issues arising from mass gathering religious and sporting events. *Lancet* 2019;393:2073–84.
120. Blyth CC, Foo H, van Hal SJ, *et al.* Influenza outbreaks during world youth day 2008 mass gathering. *Emerg Infect Dis* 2010;16:809–15.
121. Santibanez S, Prosenc K, Lohr D *et al.* Measles virus spread initiated at international mass gatherings in Europe, 2011. *Eurosurveillance* 2014;19:20891. doi:10.2807/1560-7917.es2014.19.35.20891
122. WHO. *Advice on the Use of Masks in the Context of COVID-19: Interim Guidance*, 5 June 2020.; 2020. Geneva: World Health Organization. doi:10.1093/jiaa077
123. WHO. *Advice on the Use of Masks in the Context of COVID-19: Interim Guidance*, 6 April 2020.; 2020. Geneva: World Health Organization. doi:10.1093/jiaa077
124. Omarova A, Tussupova K, Hjorth P *et al.* Water supply challenges in rural areas: a case study from Central Kazakhstan. *Int J Environ Res Public Health* 2019;16:688. doi:10.3390/ijerph16050688
125. Kiyu A, Hardin S. Functioning and utilization of rural water supplies in Sarawak, *Malaysia Bull World Health Organ* 1992;70:125–8.
126. Busienei PJ, Ogendi GM, Mokua MA. Open defecation practices in Lodwar, Kenya: a mixed-methods research. *Environ Health Insights* 2019;13:1–13.
127. Grayson ML, Melvani S, Druce J, *et al.* Efficacy of soap and water and alcohol-Based hand-Rub preparations against live H1N1 influenza virus on the hands of human volunteers. *Clin Infect Dis* 2009;48:285–91.
128. Tuladhar E, Hazeleger WC, Koopmans M *et al.* Reducing viral contamination from finger pads: Handwashing is more effective than alcohol-based hand disinfectants. *J Hosp Infect* 2015;90:226–34.
129. Chan EYY, Cheng CK, Tam G *et al.* Knowledge, attitudes, and practices of Hong Kong population towards human a/H7N9 influenza pandemic preparedness, China, 2014 infectious disease epidemiology. *BMC Public Health* 2015;15:1–10.
130. World Health Organization. *Health education: theoretical concepts, effective strategies and core competencies: A foundation document to guide capacity development of health educators*. Cairo: World Health Organization Regional Office for the Eastern Mediterranean; 2012. Accessed May 17, 2020. https://apps.who.int/iris/handle/10665/119953
131. Hamamura T, Park JH. Regional differences in pathogen prevalence and defensive reactions to the 'swine flu' outbreak among east Asians and westerners. *Evol Psychol* 2010;8:506–515.
132. Borkow G, Zhou SS, Page T *et al.* A novel anti-influenza copper oxide containing respiratory face mask. *PLoS One* 2010;5:e11295. doi:10.1371/journal.pone.0011295
133. Kim K-H, Song D-J, Yu M-H *et al.* Hazard classification of household chemical products in Korea according to the globally harmonized system of classification and labeling of chemicals. *Ann Occup Environ Med* 2013;25:11. doi: 10.1186/2052-4374-25-11.
134. The government of the Hong Kong special administrative region. *CuMask+*. 2020. Accessed May 17, 2020. https://www.qmask.gov.hk/en/about
135. Wilder-Smith A, Freedman DO. Isolation, quarantine, social distancing and community containment: pivotal role for old-style public health measures in the novel coronavirus (2019-nCoV) outbreak. *J Travel Med* 2020;27:1–4.
136. Wong SYS, Kin On K, Chan FKL. What can countries learn from Hong Kong's response to the COVID-19 pandemic? *Can Med Assoc J* 2020;192:e511-e515.
137. Chan KH, Yuen KY. COVID-19 epidemic: disentangling the re-emerging controversy about medical facemasks from an epidemiological perspective. *Int J Epidemiol* 2020;1–4.

138. Servick K. Would everyone wearing face masks help us slow the pandemic? *Science* . doi: 10.1126/science.abb9371.

139. Zhang H, Shaw R. Identifying research trends and gaps in the context of covid-19. *Int J Environ Res Public Health* 2020;17:3370. doi:10.3390/ijerph17103370

Appendix 1. Keywords and phrases searched, by subject grouping

Subject group		Keyword or phrases searched
Virus	COVID-specific	COVID-19
		SARS-CoV-2
		COVID-19 stability
		2019-nCOV
		SARS-CoV-2 entry points
		COVID-19 policies
		WHO COVID-19
		CDC COVID-19
		COVID-19 advice
		Ethics COVID-19
	Other related viruses	Droplet transmission
		Virus
		Coronavirus treatment
		Severe acute respiratory syndrome
		SARS
		Coronavirus
		Enveloped viruses
		Respiratory virus
		Respiratory hygiene
		Respiratory emission
Public Health	Epidemiology	Epidemiology
		Transmission
		Virus stability
		Virus transmission
		Host responses to virus
		Virus outbreak
	Prevention and management	Health-EDRM
		Risk management
		Global health
		Prevention
		Infection risk reduction
		Hygiene education
Primary prevention practices	Personal	Air pollution
		Handwashing
		Pollution mask
		Face masks
		Rural handwashing
		Face touching
		Coughing and sneezing
		Toilet plume
	Household	Disinfection
		Biocidal agents virus
		Utensil sharing risk
		Cutlery sharing risk
		Phone hygiene
		Sodium hypochlorite disinfection
		Open defecation
	Community	Mass gatherings
		Social isolation
		Quarantine
		Social distancing

Appendix 2. Relevant measure(s), study design, relevant key finding(s) and/or conclusion of each utilized reference

Ref. No.	Title	Journal or publication	Date of publication	Relevant measure(s) (See Key 1)	OCEBM Level of Evidence based on study design (See Key 2)	Relevant key finding(s) and/or conclusion
4	Modes of Transmission of Virus Causing COVID-19: Implications for IPC Precaution Recommendations	WHO Scientific Brief	March 2020	A, B, I	Level 5: Expert opinion on precaution recommendations, using research on the characteristics of COVID-19	• With knowledge of droplet transmission (and particle size), droplet and contact precautions are recommended for COVID-19 • Importance of PPE and other practices such as frequent hand hygiene is indicated
19	COVID-19: A Call for Physical Scientists and Engineers	American Chemical Society NANO	April 2020	A, D, H, I	Level 5: Expert opinion based on clinicians' experiences and knowledge; presentation of questions, hypotheses and research needs regarding COVID-19	• Elucidates basic biology of viruses and their transmission and infection pathway • Importance of handwashing and hygiene is demonstrated via explanation of the need to deactivate released virions before they reach a host • Identifies the major complications and understandings associated with current measures such as PPE and surface sanitization and make recommendations accordingly
20	Aerosol and Surface Stability of SARS-CoV-2 as Compared with SARS-CoV-1	The New England Journal of Medicine	April 2020	A, C, D, J	Level 5: An *in vitro* study of the surface stability of the SARS-Cov-2 strain compared to SARS-CoV-1	• SARS-CoV-2 has similar surface stability compared to SARS-CoV-1 under experimental circumstances • Demonstrates stability on surfaces such as plastic and stainless steel with potential for aerosol and fomite transmission
21	Community Transmission of Severe Acute Respiratory Syndrome Coronavirus 2, Shenzhen, China, 2020	Emerging Infectious Diseases	June 2020 (Early Release)	B	Level 4: A case series on confirmed COVID-19 studied in order to understand the pattern of community transmission	• COVID-19 became endemic to Shenzhen. Community, intrafamily and nosocomial transmission routes were found. • Maintenance strategies are derived, such as minimizing public activity, using personal protection measures and the importance of early screening, diagnosis and isolation

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Appendix 2. Continued

Ref. No.	Title	Journal or publication	Date of publication	Relevant measure(s) (See Key 1)	OCEBM Level of Evidence based on study design (See Key 2)	Relevant key finding(s) and/or conclusion
[22]	A Familial Cluster of Pneumonia Associated with the 2019 Novel Coronavirus Indicating Person-to-Person Transmission: A Study of a Family Cluster	The Lancet	February 2020	B	Level 4: A case series exploring epidemiological, clinical, laboratory, radiology and microbiological findings of a family cluster of (initially) unexplained pneumonia	• Indicating person-to-person transmission via nosocomial and intrafamily means • Noted that many findings were similar to those of SARS patients in 2003 • One patient was initially asymptomatic—suggestion for early tracing, quarantine and control measures
[23]	Tropism and Innate Host Responses of Influenza A/H5N6 Virus: An Analysis of Ex Vivo and In Vitro Cultures of the Human Respiratory Tract	European Respiratory Journal	March 2017	B	Level 5: An *in vitro* study on tropism, replication competence and cytokine induction of virus isolates in cultures (*Ex Vivo* and *In Vitro*) derived from human respiratory tract	• Human H5N6 virus adapted to human airways, indicating a risk pattern for the virus upon entry into respiratory tract
[24]	2019-nCoV Transmission Through the Ocular Surface Must Not Be Ignored	The Lancet	February 2020	B	Level 5: An ophthalmologist's expert perspective on additional risk through mucous membrane of eyes	• Suggestion for consideration of studies into conjunctival scrapings to look for signs of ocular transmission • Ophthalmologists must wear protective eyewear when examining suspect cases
[25]	Presumed Asymptomatic Carrier Transmission of COVID-19	Journal of the American Medical Association	February 2020	A, B, D, I, J, H	Level 4: A case series on a familial cluster of five patients with COVID-19	• There is a potential mechanism of COVID-19 transmission via an asymptomatic carrier • Further study on the relevant mechanism is suggested
[26]	Emergencies Preparedness, Response: What Can I Do?	WHO	January 2010	B	Level 5: A compilation of information on pandemic response (2009 H1N1) protective measures	• Regarding masks specifically, it suggests that masks are only needed if you are sick • Remarks on the importance of proper mask-wearing practice if the measure is adopted

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Appendix 2. Continued

Ref. No.	Title	Journal or publication	Date of publication	Relevant measure(s) (See Key 1)	OCEBM Level of Evidence based on study design (See Key 2)	Relevant key finding(s) and/or conclusion
27	SARS-CoV-2 Entry Factors Are Highly Expressed in Nasal Epithelial Cells Together with Innate Immune Genes	Nature Medicine	April 2020	B, C	Level 5: A study on SARS-CoV-2 tropism study via study of expression of viral entry-associated genes	• Genes found to be co-expressed in nasal epithelial cells, indicating a role in the initial phase of viral infection, spread and clearance
28	Use of Disposable Face Masks for Public Health Protection against SARS	Journal of Epidemiology and Community Health	April 2004	A, B	Level 5: Expert opinion on the use of face masks and practice of personal hygiene as important measures to protect the general public from SARS	• States that protection against SARS for healthcare workers is different from the general public, as the latter is not subject to continuous exposure to droplet transmission from an infected patient • Expresses reduced risk of aerosol droplet transmission with masks • Notes importance of proper usage and frequent changing of masks • Also extends to mention importance of other personal hygiene practices such as handwashing due to survival of the virus on surfaces
29	SARS Transmission, Risk Factors, and Prevention in Hong Kong	Emerging Infectious Diseases	April 2004	A, B, G	Level 3b: A case–control study to compare SARS case patients with undefined sources of infection with community controls	• Concluded that risk factors for SARS infection include visiting mainland China, hospitals and the Amoy Gardens (an estate with a SARS outbreak) • Indicates that frequent mask use in public venues, frequent handwashing and household disinfection were prominent protective factors
30	Respiratory Infections during SARS Outbreak, Hong Kong, 2003	Emerging Infectious Diseases	November 2005	A, B, D, G	Level 4: A cross-sectional study to compare the proportion of respiratory virus-positive specimens in 2003 and those from 1998 to 2002	• No direct causal relationship was established • However, the study suggests a positive association between reduced influenza/respiratory infection incidence and population-based hygienic measures including face mask wearing, hand washing after contact with potentially contaminated objects, using soap for handwashing, mouth covering when sneezing or coughing and household disinfection

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Appendix 2. Continued

Ref. No.	Title	Journal or publication	Date of publication	Relevant measure(s) (See Key 1)	OCEBM Level of Evidence based on study design (See Key 2)	Relevant key finding(s) and/or conclusion
31	Controlling the Novel A (H1N1) Influenza Virus: Don't Touch Your Face!	The Journal of Hospital Infection	November 2009	A, C	Level 5: A letter to the editor on a study of surface swab specimens from patients with confirmed influenza A	• Indicates that virus strains of influenza A are found in surfaces such as bed rails, walls and sofas • Further implies the importance of hand hygiene, droplet and contact precautions and behavioural conditioning such as avoiding touching of the nose, eye or mouth to prevent and control influenza
32	Stopping the Spread of COVID-19	Journal of the American Medical Association	March 2020	A, C, D, G, I	Level 5: A set of guidelines with potential measures to stop the spread of COVID-19	• Different methods of infection prevention including hand hygiene, social distancing, household disinfection and general personal hygiene are suggested
33	Prevention of Coronavirus Disease 2019 (COVID-19)	Hong Kong Centre for Health Protection	May 2020	A, B, C, D, F, G, I, J	Level 5: A set of guidelines with information related to COVID-19 such as prevention suggestions and clinical features of the coronavirus	• Prevention advice such as mask wearing, avoidance of face touching, covering mouth and nose, putting the toilet lid down when flushing and general travel advice is suggested
34	Fact Sheet for SARS Patients and Their Close Contact	Centres for Disease Control and Prevention	2003	A, B, C, D, E, F, H, I, J	Level 5: A set of guidelines with information related to SARS such as symptoms, mode of transmission and prevention measures	• Personal protection measures, such as the avoidance of silverware sharing, handwashing and covering mouth and nose when coughing or sneezing, are recommended
35	WHO Guidelines on Hand Hygiene in Health Care	WHO	2009	A	Level 5: An extensive evidence-based guideline on the practice and science behind handwashing	• Extensive findings on best handwashing practice and efficacy of soap-based washing and alcohol against enveloped viruses
36	Simplifying the World Health Organization Protocol: 3 Steps Versus 6 Steps for Performance of Hand Hygiene in a Cluster-Randomized Trial	Clinical Infectious Diseases	August 2019	A	Level 1b: A cluster-randomized trial assigning three-step versus six-step handwashing protocol	• Findings suggest that both significantly reduced the bacterial colony (with no significant difference between the two) but that the three-step guidelines had higher compliance Quantity of steps is not of great concern as long as areas are covered

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Appendix 2. Continued

Ref. No.	Title	Journal or publication	Date of publication	Relevant measure(s) (See Key 1)	OCEBM Level of Evidence based on study design (See Key 2)	Relevant key finding(s) and/or conclusion
37	The Common Missed Handwashing Instances and Areas after 15 Years of Hand-Hygiene Education	Journal of Environmental and Public Health	August 2019	A	Level 4: A cross-sectional study looking at a cohort in Hong Kong and their handwashing and hand hygiene practices	• Indicates several areas of the hands which are commonly missed, as well as occasions during which handwashing should be performed • Relationship between age or education and hand hygiene practice is indicated
38	Hygiene and Health: Systematic Review of Handwashing Practices Worldwide and Update of Health Effects	Tropical Medicine and International Health	May 2014	A	Level 1a: A systematic review of RCTs and quasi-randomized trials (+others). Studies observed rates of handwashing with soap in various populations and scenarios	• Significant global problem regarding poor practice of handwashing after contact with excrete is found
39	Assessment of Hand Hygiene Techniques Using the World Health Organization's Six Steps	Journal of Infection and Public Health	December 2015	A	Level 2b: An individual cohort study observing hand hygiene techniques over a period of 5 months	• Certain areas of the hand achieved lower areas of compliance during handwashing
40	Bacteriological Aspects of Hand Washing: A Key for Health Promotion and Infections Control	International Journal of Preventative Medicine	March 2017	A	Level 3a: A systematic review of case–control studies	• Handwashing can reduce infectious agent's transmission in the community and healthcare settings
41	Coronavirus Disease (COVID-19) Advice for the Public	WHO	April 2020	A, B, C, D, I	Level 5: Expert opinion on personal protection from COVID-19 such as safe use of alcohol-based hand sanitizers	• Informs the public of the importance of actions such as regular handwashing with soap and water; cleaning hands with alcohol-based rub; social distancing; avoiding crowds; avoiding eye, nose, mouth touching; covering mouth and nose; staying home and health-seeking behaviour under the pandemic • Precautions on alcohol-based hand sanitizer use are also mentioned
42	How to Protect Yourself & Others	Centres for Disease Control and Prevention	April 2020	A, B, D, G, I	Level 5: Expert opinion on how COVID-19 spreads and personal protection measures for COVID-19	• Informs the public of person-to-person spread of the virus, the lack of vaccine to prevent COVID-19 and the importance of actions such as regular handwashing with soap and water, avoiding close contact, covering mouse and nose with a cloth face cover, covering coughs and sneezes, as well as cleaning and disinfecting frequently touched surfaces and households under the pandemic

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Appendix 2. Continued

Ref. No.	Title	Journal or publication	Date of publication	Relevant measure(s) (See Key 1)	OCEBM Level of Evidence based on study design (See Key 2)	Relevant key finding(s) and/or conclusion
43	Hand Hygiene and the Novel Coronavirus Pandemic: The Role of Healthcare Workers	The Journal of Hospital Infection	March 2020	A	Level 5: Expert opinion on the importance of practicing respiratory and hand hygiene, as well as using personal protective equipment in healthcare settings	• Details the role of healthcare workers, nurses and midwives in providing primary point of care in communities and for pregnant women, respectively, especially during infectious disease outbreaks • Mentions details and precautions when using alcohol-based hand rubs for hand hygiene
44	A Schlieren Optical Study of the Human Cough With and Without Wearing Masks for Aerosol Infection Control	Journal of the Royal Society, Interface	December 2009	B, D	Level 5: A study comparing the fluid dynamics of coughing with or without standard surgical or N95 mask wearing using video records	• Human coughing projects a rapid turbulent jet into the surrounding air • Wearing a surgical or N95 mask interrupts the natural mechanism of airborne infection transmission through blocking turbulent jet formation (N95 mask) or redirecting the exhalant (surgical mask)
45	Respiratory Virus Shedding in Exhaled Breath and Efficacy of Face Masks	Nature Medicine	April 2020	B	Level 1b: A randomized controlled trial comparing exhaled breath samples (for respiratory virus shedding) in mask-wearing versus non-mask-wearing individuals	• Surgical face masks can prevent transmission of human coronaviruses and influenza viruses from symptomatic individuals • Surgical face masks reduce detection of coronavirus RNA in aerosols, with a trend towards reduced detection of coronavirus RNA in respiratory droplets
46	Early Transmission Dynamics in Wuhan, China, of Novel Coronavirus-Infected Pneumonia	The New England Journal of Medicine	January 2020	B	Level 4: A case series looking at characteristics and illness timelines of laboratory confirmed cases of COVID-19	• Human-to-human transmission has occurred and that measures must be implemented towards populations at risk
47	Contamination by Respiratory Viruses on Outer Surface of Medical Masks Used by Hospital Healthcare Workers	BMC Infectious Diseases	June 2019	B	Level 1b: An individual randomized controlled trial with two pilot studies (cohort). Participants told to wear medical masks and then masks were checked for respiratory viruses on the surface	• Virus presence on the face mask was higher when worn for a longer period of time (in the 6> subgroup) • The study concluded that because of this risk, the pathogens on the outer surface may cause self-contamination, with greater risk when worn for >6 hours • Indications that there should be a maximum time on mask usage

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Appendix 2. Continued

Ref. No.	Title	Journal or publication	Date of publication	Relevant measure(s) (See Key 1)	OCEBM Level of Evidence based on study design (See Key 2)	Relevant key finding(s) and/or conclusion
48	Stability of SARS-CoV-2 in Different Environmental Conditions	The Lancet	May 2020	B, G	Level 5: An experimental study on the stability of COVID-19 in different induced environmental conditions such as under heat stress and on different surfaces	• Infectious virus was not detected after 5-minute incubation at room temperature • Virus found to be stable at wide range of pH, and stable on surfaces such as outer lay of surgical masks • Virus was susceptible to disinfection methods
49	What You Need to Know About Infectious Disease	US Institute of Medicine	2010	C, D	Level 5: A book that contains expert opinion on infectious diseases and the nature of their transmission	• The mouth, the eyes and the nose are the body's main entry points for transmittable conditions such as influenza • Coughing and sneezing facilitate the spread of droplet transmittable diseases
50	Face Touching: A Frequent Habit that Has Implications for Hand Hygiene	American Journal of Infection Control	February 2015	C	Level 2b: A behavioural observation study of 26 participants exploring the habit of face touching	• Even among medical students, there was frequent face touching behaviour • This indicates towards the importance of hand hygiene too apart from the risk of self-inoculation from face touching which needs to be elucidated
51	Self-touch: Contact Durations and Point of Touch of Spontaneous Facial Self-touches Differ Depending on Cognitive and Emotional Load	PLOS ONE Medicine (Baltimore)	March 2019	C	Level 2b: A cohort study exploring the behaviour of face touching and its link to cognitive and emotional loads	• Results showed that both the point of touch and contact durations were under influence from emotional and cognitive triggers
52	Protective Effect of Hand-washing and Good Hygienic Habits against Seasonal Influenza: A Case–Control Study	Medicine (Baltimore)	March 2016	A	Level 3b: A single case–control study testing the link between influenza transmission and self-reported handwashing/unhealthy hygiene habits	• Frequent handwashing and better hygiene habits were associated with a reduction in the risk of influenza infection
53	Hand Hygiene and Risk of Influenza Virus Infections in the Community: A Systematic Review and Meta-analysis	Epidemiology & Infection	May 2014	A	Level 1a: A systematic review of 10 randomized controlled trials aiming to evaluate the efficacy of hand hygiene measures against the reduction of influenza transmission	• Findings suggested that while hand washing may be effective (modest efficacy) against one mode of transmission, i.e. contact, further measures may also be important to control influenza transmission, for example face masks

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Appendix 2. Continued

Ref. No.	Title	Journal or publication	Date of publication	Relevant measure(s) (See Key 1)	OCEBM Level of Evidence based on study design (See Key 2)	Relevant key finding(s) and/or conclusion
54	Effect of Washing Hands with Soap on Diarrhoea Risk in the Community: A Systematic Review	Cochrane Database of Systematic Reviews	September 2015	A	Level 1a: A systematic review of 22 randomized controlled trials to compare diarrhoea occurrence in children and adults with or without handwashing measures	• Handwashing measures result in diarrhoea episode reductions in child day care centres in high-income countries as well as communities in low- and middle-income countries • It is a challenge to encourage the habitual maintenance of handwashing habits in people in the long term
55	Hand Washing Promotion for Preventing Diarrhoea	Cochrane Systematic Review	September 2015	A	Level 1a: A systematic review of randomized controlled trials and cluster RCTs to compare the effects of measures associated with handwashing on the occurrence of diarrhoea episodes in children	• Hand washing most likely reduces diarrhoea episodes in certain communities, as per the study's findings • There may be lack of understanding on how to help people maintain habits related to handwashing in the long term
56	Reducing the Risk of Infection: Hand Washing Technique	Community Eye Health	March 2008	A	Level 5: Expert guidance on components of a good handwashing route	Indicates that handwashing is critical to infection control and that there may be inadequate awareness on importance of handwashing techniques, which may be impeding effectiveness
57	The Effectiveness of Hand Hygiene Procedures in Reducing the Risks of Infections in Home and Community Settings Including Handwashing and Alcohol-Based Hand Sanitizers	American Journal of Infection Control	December 2007	A	Level 5: A report reviewing the evidence on hand hygiene and its link to infectious disease transmissions	• Hand hygiene is a significant component of good hygiene in households and communities and has significant benefit towards the reduction of infection transmission, including respiratory tract infections • Further conclusion that hand hygiene's impact towards infectious disease reduction can be enhanced by improved persuasion of community handwashing (properly and at the right times) and that hand hygiene promotion should come hand in hand with other aspects of hygiene and associated education
58	Effectiveness of Commercial Face Masks to Reduce Personal PM Exposure	Science of the Total Environment	September 2018	B	Level 5: A model-based study evaluating the efficacy of face mask respirators towards the reduction of airborne particle exposure and subsequent pollutant exposure	• Facemasks reduce exposure to urban pollution The efficacy of available face masks can vary in achieving exposure reduction to urban pollution

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Appendix 2. Continued

Ref. No.	Title	Journal or publication	Date of publication	Relevant measure(s) (See Key 1)	OCEBM Level of Evidence based on study design (See Key 2)	Relevant key finding(s) and/or conclusion
59	Exploring Motivations behind Pollution-Mask Use in a Sample of Young Adults in Urban China	Globalization and Health	December 2018	B	Level 4: A cross-sectional survey exploring the role of socio-cognitive factors in affecting the decision of wearing a pollution mask in the context of young educated people	• Mask-wearing practice is influenced by various reasons including but not limited to level of education, social norms, self-efficacy, attitudes and past behaviour • The conclusion indicates the need towards changing the social perception towards mask-wearing practice
60	WHO | Air Pollution	WHO	N/A	B, I	Level 5: A collection of resources including global data on air pollution and subsequent protective measures	• Demonstrates that 9/10 people breathe air containing high levels of pollutants and concludes these as risk factors towards health
61	Air Pollution: A Smoking Gun for Cancer	Chinese Journal of Cancer	April 2014	B	Level 5: A review on various articles to discuss key questions surrounding the link of air pollution with cancer incidence, with a focus on China	• Air pollution was and is a risk for cancer; it makes final recommendations such as the need for personal pollution monitoring devices as well as increase international collaborations upon this matter
62	A Retrospective Approach to Assess Human Health Risks Associated with Growing Air Pollution in Urbanized Area of Thar Desert, Western Rajasthan, India	Journal of Environmental Health Science and Engineering	January 2014	B	Level 2b: A retrospective cohort study looking into the air pollution measures and associated statistics on disease burden	• Environmental burden of disease and association to air pollution is a main concern in the fast-developing areas of India • Households exposed to high vehicle-caused pollution presented with greater prevalence of respiratory diseases for example
63	Saliva and Viral Infections	Periodontology 2000	December 2015	C, E	Level 5: A review on various publications associated with viral infections via the oral cavity and discussing assays	• Regarding saliva and its role in viral infections, it indicates that it plays a key role and that the mouth and eye are common sites for viral entry • Conclusion that the oral cavity is a significant area for infection as well as virus transmission
64	Detection of Bacterial Pathogens in the Hands of Rural School Children Across Different Age Groups and Emphasizing the Importance of Hand Wash	Journal of Preventive Medicine and Hygiene	June 2019	C	Level 4: A cross-sectional observational study on hand pathogens in 200 rural school children	• Concluded that in this rural-based cohort, the hands of the children were harbouring various, potentially fatal, pathogenic organisms and could thus be a major source of infection • Indication towards the importance of hand washing and the need to provide materials (which are not available to these groups) in order to reduce spread of infection, which is otherwise reducible via hand hygiene

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Appendix 2. Continued

Ref. No.	Title	Journal or publication	Date of publication	Relevant measure(s) (See Key 1)	OCEBM Level of Evidence based on study design (See Key 2)	Relevant key finding(s) and/or conclusion
65	Viricidal Activity of World Health Organization-Recommended Formulations Against Enveloped Viruses, Including Zika, Ebola, and Emerging Coronaviruses	The Journal of Infectious Diseases	March 2017	A	Level 5: An *in vitro* experiment testing the efficacy of two WHO recommended alcohol-based formulations against different enveloped viruses	• WHO recommended alcohol-based formulations worked against the different enveloped viruses and the viricidal effect was strong
66	Effect of Handwashing on Child Health: A Randomised Controlled Trial	The Lancet	July 2005	A	Level 1b: A randomized controlled trial randomly assigning of handwashing promotion to one group and no promotion to the other versus randomized controls. Outcomes explored included diarrhoea and acute respiratory tract infections	• Study found that households receiving plain soap with handwashing promotion had lower incidence of the studied infections and that there was not much difference between plain versus antibacterial soap • Indicates the importance of such programs and distribution of soap • Concluding that handwashing was effective in preventing conditions like diarrhoea and respiratory disease
67	Hand Cleaning with Ash for Reducing the Spread of Viral and Bacterial Infections: A Rapid Review	Cochrane	April 2020	A	Level 5: A systematic review using different types of studies to assess the advantages and disadvantages of ash as an alternative to soap or other materials against viruses and bacteria	• Studies were unreliable and rarely adequate examined rate of infection. Therefore, ash could not be concluded as a suitable alternative
68	Comparison of Four Methods of Hand Washing in Situations of Inadequate Water Supply	West African Journal of Medicine	January 2008	A	Level 1b: A randomized controlled trial comparing different methods of hand washing developed for use in developing countries	• The 'Elbow way' of handwashing is the gold standard with no evidence of post-contamination • Bucket and bowl as well as the single-bowl method result in cross contamination
69	Testing the Efficacy of Homemade Masks: Would They Protect in an Influenza Pandemic?	Disaster Medicine and Public Health Preparedness	August 2013	A	Level 1b: A randomized controlled trial on the effectiveness of different household materials in making homemade masks as an alternative to commercial face masks	• While a homemade mask also results in a decrease in number of microorganisms expelled by volunteers, a homemade mask is significantly less effective than surgical masks and should only be a last resort for droplet transmission prevention
70	Aerosol Filtration Efficiency of Common Fabrics Used in Respiratory Cloth Masks	American Chemical Society Nano	April 2020	B	Level 5: An experimental approach to assess common fabrics (such as cotton) and their filtration efficiencies	• Found that in general, cloth masks could potentially offer notable protection against transmission of particles, which have sizes within the aerosol range • Further findings on factors limiting effectiveness such as leakages due to fitting issues and influence of factors such as humidity, repeated use and washing

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Appendix 2. Continued

Ref. No.	Title	Journal or publication	Date of publication	Relevant measure(s) (See Key 1)	OCEBM Level of Evidence based on study design (See Key 2)	Relevant key finding(s) and/or conclusion
71	Handwashing: Clean Hands Save Lives	Journal of Consumer Health on the Internet	February 2020	A	Level 5: An expert collection of information on handwashing as well as the explanations behind it	Collects the key points on handwashing as well as the science behind the measure to ultimately make recommendations regarding when to wash and how to wash
72	Effectiveness of Handwashing in Preventing SARS: A Review	Tropical Medicine and International Health	September 2006	A	Level 3a: A systematic review of case–control studies to evaluate effectiveness of handwashing in protecting against SARS transmission	• Only three studies out of the 10 reviewed were statistically significant • While there is no conclusive evidence on the effectiveness of handwashing, this measure remains suggestive to protect against SARS transmission in the community and healthcare settings
73	Efficacy of Handwashing Duration and Drying Methods	International Association for Food Protection	July 2012	A	Level 1b: A randomized controlled trial on the impact of soap or plain water, duration of practice, presence of debris and drying method on microorganism removal from hands through handwashing	• The use of soap, longer duration of handwashing and towel drying significantly remove microorganisms compared to plain water, shorter duration and air drying, respectively • Towel drying presented with a greater person-to-person variability. The presence of food debris made handwashing less effective
74	Risk Factors for SARS among Persons Without Known Contact with SARS Patients, Beijing, China	Emerging Infectious Diseases	February 2004	B	Level 3b: An individual case–control study to compare unlinked probable SARS patients with other community-based controls	• Concluded that chronic medical conditions, visit to fever clinics, eating outside home and frequent taxi taking were risk factors in case patients • Also indicated that mask wearing is strongly protective in reducing risk for SARS
75	Mass Masking in the COVID-19 Epidemic: People Need Guidance	The Lancet	March 2020	B	Level 5: Expert opinion on the importance of plans for mass masking adoptions in the community under the emergence of COVID-19	• Indicates that compulsory social distancing and mass masking are the measures that appear to be temporarily successful in China • Expresses that while the efficacy of mask wearing may be lacking evidence, the absence of evidence should not be equated to inefficacy, especially in the context of COVID-19 with limited alternatives. • Suggests that masking can intercept the transmission link and urges governments and health authorities to make advance preparations on mass masking locally to prepare for challenges ahead
76	The Role of Community-Wide Wearing of Face Mask for Control of Coronavirus Disease 2019 (COVID-19) Epidemic due to SARS-CoV-2	Journal of Infection	April 2020	B	Level 4: A cross-sectional observational study with epidemiological analysis on COVID-19 confirmed cases in Hong Kong with community-wide masking and that of non-mask-wearing countries	• Community-wide mask wearing may potentially improve COVID-19 control through reducing infected saliva and respiratory droplet emission from infected individuals

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Appendix 2. Continued

Ref. No.	Title	Journal or publication	Date of publication	Relevant measure(s) (See Key 1)	OCEBM Level of Evidence based on study design (See Key 2)	Relevant key finding(s) and/or conclusion
77	WHO Coronavirus Disease (COVID-19) Dashboard	WHO	N/A	B	Others: Provides latest figures on COVID-19 new cases, confirmed cases and deaths in a timely manner	• Latest figure updates on COVID-19
78	To Mask or Not to Mask: Modelling the Potential for Face Mask Use by the General Public to Curtail the COVID-19 Pandemic	Infectious Disease Modelling	April 2020	B, I	Level 5: A study on hypothetical mask adoption scenarios. Proposed model simulations were used to evaluate the effect of mask-wearing on mortality reduction and reduced COVID-19 transmission.	• Mask wearing by the general public may be potentially effective in reducing community transmission and relieving the pandemic burden • Suggests that the community-wide benefits are likely to be the most significant when face masks are used with other protection practices such as social distancing, and when adoption is nearly universal with a high compliance
79	Persistence of Coronaviruses on Inanimate Surfaces and Their Inactivation with Biocidal Agents	The Journal of Hospital Infection	March 2020	C, G	Level 5: A literature review on the persistence of coronaviruses on inanimate surfaces and chemical disinfection strategies for biocidal agent inactivation	• Human coronaviruses can persist on inanimate surfaces like metal, glass or plastic for up to 9 days • They can be efficiently inactivated using biocidal agents • Early containment and prevention of further COVID-19 spread is crucial
80	Turbulent Gas Clouds and Respiratory Pathogen Emissions: Potential Implications for Reducing Transmission of COVID-19	Journal of the American Medical Association JAMA	March 2020	D, I	Level 5: Expert opinion on turbulent gas clouds and respiratory pathogen emissions	• Suggests that pathogen-bearing droplets from a human sneeze can travel up to 7–8 m under forward momentum of the gas cloud • Indicates implications for prevention and precaution in COVID-19, including maintenance of distance away from infected individuals in healthcare settings
81	Human Saliva: Non-invasive Fluid for Detecting Novel Coronavirus (2019-nCoV)	International Journal of Environmental Research and Public Health	March 2020	E, H	Level 4: A case series on viral detection in saliva samples of COVID-19 patients on the first day of hospitalization	• Indicates consistent detection of coronavirus in saliva of COVID-19 patients admitted from first day of hospitalization • Demonstrates advantage of saliva sampling comfortability in epidemic situations such as COVID-19 • Suggests further investigation on human saliva diagnostic capacity for coronaviruses
82	Consistent Detection of 2019 Novel Coronavirus in Saliva	Clinical Infectious Diseases	Feb 2020	E, H	Level 4: A case series on saliva viral load in self-collected saliva of COVID-19 patients	• Indicates consistent detection of live virus in saliva by viral culture • Suggests that saliva sampling is a promising and non-invasive method with high diagnostic, monitoring and infection control capacity in patients with COVID-19 infection

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Appendix 2. Continued

Ref. No.	Title	Journal or publication	Date of publication	Relevant measure(s) (See Key 1)	OCEBM Level of Evidence based on study design (See Key 2)	Relevant key finding(s) and/or conclusion
83	Microbiological Contamination of Environments and Surfaces at Commercial Restaurants	Ciência & Saúde Coletiva	2010	E	Level 5: A study on the levels of microbiological contamination on restaurant surfaces	• Extensive contamination by bacteria was observed in restaurant surfaces such as utensils, equipment and stainless steel benches • Suggests further sanitary measure to reduce risks of foodborne diseases
84	Contamination by *Bacillus cereus* on Equipment and Utensil Surfaces in a Food and Nutrition Service Unit	Ciência & Saúde Coletiva	September 2011	E	Level 5: A study on the levels of microbiological contamination in food processing plants	Significant contamination by bacteria was identified in over 30% of the equipment and utensils studied in food processing plants
85	Detectable SARS-CoV-2 Viral RNA in Faeces of Three Children During Recovery Period of COVID-19 Pneumonia	Journal of Medical Virology	March 2020	F	Level 4: A case series in which information of COVID-19 infected children was collected, such as clinical characteristics and chest imaging	Concluded that SARS-CoV-2 viral RNA is detectable in the faecal samples of three children during their recovery from COVID-19 pneumonia
86	CUHK Finds that the Coronavirus Can Persist in Stool after Its Clearance in Respiratory Tract; Will Conduct Stool Test for People in Quarantine Camps for Early Identification	The Chinese University of Hong Kong	March 2020	F, J	Level 4: A case series on the viral load of faecal samples from COVID-19 patients	• Concluded that all studied patients have COVID-19 virus detected in their faecal samples • For a minority of patients, virus was still present in the faecal sample 1–2 days after the respiratory sample tested negative
87	The Potential Spread of Infection Caused by Aerosol Contamination of Surfaces after Flushing a Domestic Toilet	Journal of Applied Microbiology	June 2005	F	Level 5: A study to determine the level of aerosol formation and fall out within a toilet cubicle after toilet flushing through mimicking infectious diarrhoea	• Large numbers of microorganisms remained on the toilet bowl surface and in the bowl water, which are further dispersed to the air through further toilet flushing. • Indicates potential health risk to individuals who are unaware of this mode of transmission within the household
88	Lifting the Lid on Toilet Plume Aerosol: A Literature Review with Suggestions for Future Research	American Journal of Infection Control	October 2012	F	Level 5: A review on the potential health risks of aerosol production during toilet flushing	• Toilet plume under toilet flushing may contribute to infectious disease transmission • Further research to assess toilet plume risks, especially in healthcare settings, is encouraged
89	Respiratory Hygiene and Cough Etiquette	Infection Control in the Dental Office	April 2020	D	Level 5: Expert opinion on respiratory hygiene and cough etiquette	• Prevention is the best method for respiratory disease management • Proper hand hygiene and awareness on cough and sneeze etiquette is encouraged for successful prevention

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Appendix 2. Continued

Ref. No.	Title	Journal or publication	Date of publication	Relevant measure(s) (See Key 1)	OCEBM Level of Evidence based on study design (See Key 2)	Relevant key finding(s) and/or conclusion
90	Bacterial Transfer from Mouth to Different Utensils and from Utensils to Food	Graduate School of Clemson University	August 2009	E, H	Level 5: A study on the transfer of bacteria from mouth to different utensils	• There is a significant bacterial transfer from mouth to utensils and further to food
91	*Helicobacter pylori*: Epidemiology and Routes of Transmission	Epidemiologic Reviews	July 2000	E, H	Level 5: A review on the epidemiology and routes of transmission of *Helicobacter pylori*	• *H. pylori* infection is prevalent in Chinese immigrants in Australia who share chopsticks for communal dishes • A common mode of *H. pylori* transmission involves an oral-to-oral route through saliva
92	Potential for Aerosolization of *Clostridium difficile* after Flushing Toilets: The Role of Toilet Lids in Reducing Environmental Contamination Risk	The Journal for Hospital Infection	December 2011	F	Level 5: A study on *in situ* testing using faecal suspensions to mimic disease bacteria and measure microorganism aerosolization as well as extent of splashing when toilet flushing	• Lidless toilets may lead to environmental contamination by microogranisms and associated health risks. Use of lidless toilets is thus discouraged.
93	Mobility Decline in Old Age: A Time to Intervene	Exercise and Sport Sciences Reviews	January 2013	D	Level 5: Expert opinion on mobility impairment in ageing populations	• Mobility decline is prominent in the old aged • It is important for behavioural measures to be in place for mobility function improvement • Further rigorous clinical trials are needed • The treatment and prevention of mobility impairments through expert collaboration are essential
94	Age-related Change in Mobility: Perspectives from Life Course Epidemiology and Geroscience	The Journals of Gerontology. Series A, Biological Sciences and Medical Sciences	March 2016	D	Level 5: Expert opinion on mobility impairment in ageing populations, explored through the perspectives of epidemiology and geroscience	• Physical deterioration in older persons results in mobility loss and impairment • It is important for behavioural measures to be in place to reduce the disability burden in populations
95	Plastic Waste Inputs from Land into the Ocean	Science	February 2015	E	Level 5: A report on the estimation of plastic waste mass in oceans by linking relevant worldwide data	• The amount of plastic waste generated across 192 coastal countries is determined • The major determining factors of a country's contribution to plastic waste would be population size and waste management system quality • An estimation is made on the cumulative plastic waste quantity if waste management infrastructure is not improved
96	Microplastic Contamination of Wild and Captive Flathead Grey Mullet (*Mugil cephalus*)	International Journal of Environmental Research and Public Health	March 2018	E	Level 5: An investigation on microplastic ingestion in flathead grey mullets	• There was evidence of microplastic ingestion in the mullets • Individual, local and global actions to counteract the issue of plastic waste disposal into seas are encouraged

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Appendix 2. Continued

Ref. No.	Title	Journal or publication	Date of publication	Relevant measure(s) (See Key 1)	OCEBM Level of Evidence based on study design (See Key 2)	Relevant key finding(s) and/or conclusion
97	CityU Experts: Aerosol Droplets from Toilet Flushing Can Rise Up to One Metre; Covering Toilet Lid may not Completely Eliminate Disease Transmission; Toilet Bowl Must Be Regularly Cleaned	The City University of Hong Kong	February 2020	F	Level 5: A study on how toilet flushing may produce aerosol droplets that facilitate disease transmission	• A single toilet flush can contaminate the washroom through the spread of pathogens in the air • The covering of toilet lid before flushing for washroom and air contamination reduction is recommended • Toilet lid covering may not completely inhibit pathogenic dissemination due to potential space between the lid and the bowl
98	The Coronavirus Pandemic and Aerosols: Does COVID-19 Transmit via Expiratory Particles?	Aerosol Science and Technology	April 2020	D	Level 5: Expert opinion on the potential of COVID-19 transmission through expiratory particles	• Aerosol transmission may play a major role in the high transmissibility of COVID-19 • Ordinary speech has a potential of aerosolizing respiratory particles. • There are scientific unknowns relating to the mode of transmission It is important for experts to collaborate closely and effectively inform the public of potential infectious aerosol emission all the time, such as during coughing and sneezing
99	Air, Surface Environmental, and Personal Protective Equipment Contamination by Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) from a Symptomatic Patient	Journal of the American Medical Association	March 2020	D	Level 5: A study on the SARS-CoV-2 contamination and persistence on environmental surfaces and personal protective equipment around COVID-19 patients in isolation rooms	• Environmental contamination is a highly potential route of transmission for coronaviruses, which may contribute to incidences of nosocomial transmission of COVID-19 in hospitals • Further studies need to be conducted on the mode of transmission of COVID-19 and the extent of environmental contamination
100	Protection and Disinfection Policies against SARS-CoV-2 (COVID-19)	Le Infezioni in Medicina	2020	G	Level 5: Expert opinion on COVID-19 transmission, the stability of the virus and relevant measures of prevention	• The coronavirus can remain in airs and surfaces for sustained periods of time • Recommendation of household disinfection is made
101	Prevalence of Multidrug-Resistant Bacteria on Mobile Phone Surface	Journal of Microscopy and Ultrastructure	2020	G	Level 5: A study on multi-drug-resistant bacteria on mobile phones	• Nosocomial infection spread is accelerated by microorganism presence on the mobile phones of healthcare workers • Disinfection practices for phones in hospitals to ease potential health risks are recommended
102	Degree of Bacterial Contamination of Mobile Phone and Computer Keyboard Surfaces and Efficacy of Disinfection with Chlorhexidine Digluconate and Triclosan to Its Reduction	International Journal of Environmental Research Public Health	October 2018	G	Level 5: A study on the bacterial contamination of mobile phone and computer keyboard surfaces as well as the subsequent disinfection efficacy of selected disinfectants	• A high degree of surface contamination is found on both surfaces • Disinfection with simple antibacterial wet wipes to significantly reduce microbial contamination is recommended

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Appendix 2. Continued

Ref. No.	Title	Journal or publication	Date of publication	Relevant measure(s) (See Key 1)	OCEBM Level of Evidence based on study design (See Key 2)	Relevant key finding(s) and/or conclusion
103	Association of Household Food- and Drink-Sharing Practices with Human Herpesvirus 8 Seroconversion in a Cohort of Zambian Children	The Journal of Infectious Diseases	October 2017	H	Level 2b: An individual cohort study on the link between household food and drink sharing behaviour and the risk of HHV-8 transmission	• There is a temporal association between food- and drink-sharing practices and HHV-8 transmission • Such sharing practices should be minimized to reduce transmission risks, in particular for households with large sibling numbers
104	The Clinical Toxicology of Sodium Hypochlorite	Clinical Toxicology Philadelphia	January 2018	G	Level 5: A review on the clinical toxicology of sodium hypochlorite	The unintended ingestion of household bleach in large amounts may pose severe health risks such as corrosive injury that may be fatal
105	Occurrence of Household Mould and Efficacy of Sodium Hypochlorite Disinfectant	Journal of Occupational and Environmental Hygiene	2012	G	Level 5: A study on the appearance of household mould and the disinfecting capability of sodium hypochlorite on household surfaces	• Low concentrations of sodium hypochlorite significantly reduce mould and related allergens
106	Efficacy of Sodium Hypochlorite Disinfectant on the Viability and Allergenic Properties of Household Mould	Journal of Allergy and Clinical Immunology	February 2004	G	Level 5: A study on the efficacy of sodium hypochlorite as a disinfectant for household moulds	• Low concentrations of sodium hypochlorite significantly reduce mould and related allergens
107	Transmission of Mutans Streptococci in Mother–Child Pairs	The Indian Journal of Medical Research	August 2016	H	Level 4: A case series evaluating the transmission of dental caries (mutans streptococci) from mother to child	• A vertical transmission of mutans streptococci from mother to child is concluded • Further development of strategies to reduce food and utensil sharing between mothers and children is recommended
108	Aerosol Emission and Superemission during Human Speech Increase with Voice Loudness	Scientific Reports	February 2019	I	Level 5: A review on the potential of aerosol emission and disease transmission through human speech	• Particle emission during speech has a positive correlation with speech loudness • Respiratory infectious disease transmission is facilitated by many unknown physiological factors such as speech
109	COVID-19 Transmission through Asymptomatic Carriers Is a Challenge to Containment	Influenza and Other Respiratory Viruses	April 2020	I, J	Level 5: A review on the transmission of COVID-19 through asymptomatic individuals and the associated challenges	• Asymptomatic transmission of COVID-19 is possible between persons within communities
110	Routes of Transmission of Influenza A H1N1, SARS CoV, and Norovirus in Air Cabin: Comparative Analyses	International Journal of Indoor Environment and Health	January 2018	J	Level 5: A model simulation to assess the transmission routes of various infectious viruses	• Virus control in indoor environments such as airplanes should take into consideration respiratory and enteric transmission routes • A method to analyse the comparative significance of different modes of virus transmission is highlighted
111	Epidemiological Characteristics of the First 53 Laboratory-Confirmed Cases of COVID-19 Epidemic in Hong Kong, 13 February 2020	Eurosurveillance	April 2020	I, J	Level 4: A case series on the key epidemiological parameters of COVID-19 cases in Hong Kong	• The risk of transmission may be heightened through increased social contact • Physical distancing is a key measure to counteract the pandemic

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Appendix 2. Continued

Ref. No.	Title	Journal or publication	Date of publication	Relevant measure(s) (See Key 1)	OCEBM Level of Evidence based on study design (See Key 2)	Relevant key finding(s) and/or conclusion
112	Towards Aerodynamically Equivalent COVID19 1.5 m Social Distancing for Walking and Running	Journal Pre-Print	January 2020	I	Level 5: A mathematical model to understand the aerodynamics associated with virus transmission and the reasoning behind social distancing	• The 1.5-m social distancing suggestion may not suffice if the aerodynamics associated with walking and running is taken into consideration • Further work to understand the effect of aerodynamic factors such as headwind on droplet transmissions is necessary
113	COVID-19 Lockdowns Cause Global Air Pollution Declines with Implications for Public Health Risk	Journal Pre-Print	April 2020	I	Level 5: A study on the declination of global air pollution as a result of reduced activity in COVID-19	• Health hazards such as premature deaths and paediatric asthma associated with air pollution have been minimized as a result of reduced activity in COVID-19 • There are potential health benefits from reduced air pollutant emissions as a result of decreased economic activity during the pandemic
114	COVID-19 as a Factor Influencing Air Pollution?	Environmental Pollution	April 2020	I	Level 5: A review on the impacts of COVID-19 on air pollution	• The emergence of COVID-19 has been followed by decreased air pollution in areas like China, and subsequently a reduced number of fatalities as a result of air pollution • There are potential benefits of non-communicable disease prevention due to air pollution reduction
115	Air Pollution and Public Health: Emerging Hazards and Improved Understanding of Risk	Environmental Geochemistry and Health	June 2015	I	Level 5: A study on air pollution as an emerging public health hazard	• Air pollution is historically linked to increased respiratory and cardiovascular mortality • Air quality improvement is a significant challenge • There is a need for effective policies to ease the burden of air pollution on health hazards
116	Point of View: How Scientists Can Reduce Their Carbon Footprint	eLife	March 2016	J	Level 5: Expert opinion on the impact of reduced long-distance air travel on carbon footprint and the reduction of greenhouse gas emissions	• Carbon dioxide emissions are significantly reduced under decreased long-distance travel among the scientific community

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Appendix 2. Continued

Ref. No.	Title	Journal or publication	Date of publication	Relevant measure(s) (See Key 1)	OCEBM Level of Evidence based on study design (See Key 2)	Relevant key finding(s) and/or conclusion
117	What Is the Evidence for Mass Gatherings During Global Pandemics?	Centre for Evidence-Based Medicine	March 2020	I	Level 5: A review on the potential effects of mass gatherings on infectious diseases	• Measures involving the restriction and cancellation of mass gatherings appear important, but relevant evidence is lacking • Active analysis of risks associated to mass gatherings is encouraged on a case-by-case basis
118	Could Influenza Transmission Be Reduced by Restricting Mass Gatherings? Towards an Evidence-Based Policy Framework	Journal of Epidemiology and Global Health	August 2011	I	Level 5: A narrative analysis on the effect of mass gathering restrictions on influenza transmission risks	• While mass gathering restrictions together with other social distancing measures may help reduce transmission, the individual effects of mass gathering restriction remain inconclusive • The duration of the event and crowd density may significantly influence influenza transmission risks
119	Mass Gatherings Medicine: Public Health Issues Arising from Mass Gathering Religious and Sporting Events	The Lancet	May 2019	I	Level 5: A review on the association of mass gathering events with potential public health hazards	• Extensive crowd interactions raise burdens on health systems, especially for large-scale sporting or religious events • Further research into public health prevention and surveillance is recommended
120	Influenza Outbreaks During World Youth Day 2008 Mass Gathering	Emerging Infectious Diseases	May 2010	I	Level 5: A review on influenza outbreaks during the 2008 World Youth Day mass gathering	• Mass gatherings introduce and amplify viruses • Isolated viruses may impose unpredictable risks on communities Authorities and hospitals are responsible for managing influenza outbreaks with greater flexibility
121	Measles Virus Spread Initiated at International Mass Gatherings in Europe, 2011	Eurosurveillance	September 2014	I	Level 5: Expert analysis on the associated measles virus spread during the 2011 mass gatherings	• Transmission chains of the measles virus originated from mass sporting events • Importance of measles virus transmission chain monitoring and surveillance is reinforced

Key 1—measures

A	Engage in regular handwashing	F	Close toilet cover when flushing
B	Wear face mask	G	Disinfect household surfaces
C	Avoid touching the face	H	Avoid sharing utensils
D	Cover mouth and nose when coughing and sneezing	I	Avoid crowds and mass gatherings
E	Bring personal utensils when dining out	J	Avoid travel

Key 2—OCEBM Level of Evidence (adapted from www.cebm.net)

Level	Therapy/prevention, aetiology/harm
1a	Systematic review (SR) (with homogeneity) of randomized controlled trials (RCTs)
1b	Individual RCT (with narrow confidence interval)
1c	All or none
2a	SR (with homogeneity) of cohort studies
2b	Individual cohort study (including low quality RCT; e.g. <80% follow-up)
2c	'Outcomes' research; ecological studies
3a	SR (with homogeneity) of case–control studies
3b	Individual case–control study
4	Case series (and poor quality cohort and case–control studies)
5	Expert opinion without explicit critical appraisal, or based on physiology, bench research or 'first principles'
Others	For example, model simulations, non-human-based experiment, *in vitro* or *in situ* studies, and statistical reports or dashboards

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Managing and responding to pandemics in higher educational institutions: initial learning from COVID-19

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Abstract

Purpose – The purpose of this paper is to understand the key challenges, approaches and lessons of the higher educational institutions (HEIs) in the context of COVID-19.

Design/methodology/approach – A survey was conducted to understand the key challenges being faced by the HEIs around the world during the ongoing COVID-19 pandemic. A total of 150 responses were collected from 65 universities, located in 29 countries.

Findings – The results show that 47% of respondents with defined universities believe their institutions lacked a permanent or dedicated emergency management office, and 41% said their HEIs lacked a general business continuity plan for an emergency. In universities with BCPs, 33% of the plans do not cover biological hazards and pandemic risk management, and 60% of the plans did not include conducting any advanced simulation exercises. More than 70% the responded said their instruction, information sharing and decision-making process were timely and open. The major challenges identified were a lack of adequate preparedness for pandemic and of pandemic-specific advanced simulation exercises. The next major challenges were the change in the mode of teaching to online lectures and working from home. Based on these challenges, a set of short- and long-term recommendations were proposed.

Originality/value – This was the first survey in academic institutions in post COVID-19 context. The findings will be useful for preparing for biological and other related hazards.

Keywords COVID-19, University responses, Online classes, Shifting academic calendar, Community and local government collaboration

Paper type Research paper

1. Introduction

Coronavirus disease (COVID-19) was first reported in Chinese city of Wuhan in December 2019, was recognized by China as a new virus in the third week of January 2020. The World

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Health Organization (WHO) initially described it as a Public Health Emergency of International Concern (PHEIC) at the end of January, and finally recognized it as a pandemic on March 11, 2020 (WHO, 2020). Chronology of events in China, East Asia and several other countries have been discussed in recent publications (Hua and Shaw, 2020; Shaw *et al.*, 2020 and reference therein).

Currently, the USA has the largest number of infected people and death, and all these factors have made COVID-19 the worst pandemic in recent years. Shaw *et al.* (2020) identified the following characteristics of COVID-19:

- rapid spread;
- heightened vulnerability among aged and low immune people; and
- differential recovery rates in different countries and age groups.

In the interconnected world, the pandemic has not only affected lives but also had a strong impact on various sectors. The education sector is among the most frequently impacted service sectors from the pandemic, having already experienced SARS and MERS. The main reason for this is the closure of schools and universities, which disrupts the academic calendar and causes stress to parents and students alike. In response, many educational institutions have started offering online classes/courses and some have shifted their academic calendars to cope with this extraordinary situation.

Understanding this as the "new normal" while also thinking of possibilities for future pandemic or biological hazards and their impact on the higher educational institutions (HEIs), this paper highlights the challenges that HEIs face in starting or continuing their courses and conduct research. The purpose of the paper is to understand and learn from lessons from the responses of different universities to deal with the COVID-19 and share the lessons widely.

2. Higher educational institutions and disaster preparedness

2.1 Major issues that higher educational institutions are facing

The COVID-19 disease made a significant impact on HEIs mainly in two areas:

(1) shifting a major educational form from a face-to-face to online; and

(2) tackling the financial challenges.

Shifting in education from traditional classroom learning to online-based learning created tremendous changes for both lecturers and students. A survey conducted in India targeting 200 students showed that 74% of the respondents liked studying through online classes. Its most common reason (49%) was the flexibility of the study time. On the other hand, the biggest drawback of online classes addressed was a lack of co-curricular activities in the online education, followed by not meeting friends (Lall and Singh, 2020).

While such positive side of online-based learning has been reported, De Oliveira Araujo *et al.* (2020) emphasized the negative impact of the COVID-19 on students' mental health. Many students face anxiety and panic owing to the numerous implications for courses, assignments, seminars and thesis defenses (The Guardian, 2020). In addition, lack of self-discipline, suitable learning materials, or good learning environments were serious issues when they are self-isolated at home (Bao, 2020). The effectiveness of the online learning is also an issue in a country such as Singapore that started to embrace the use of digital platforms to facilitate teaching and learning nearly ten years ago. Some students found out that they were more easily distracted during a lecture by doing an internet surfing or talking to friends on messaging applications without any repercussions. Even though digital tools can add values to teaching and learning and online learning has become an important part of university education, going fully online is not the best long-term plan and plays a complementary role (Tan, 2020). Blended learning models could be a mainstream and take over as the norm in the future learning and education.

Another significant issue that many HEIs have faced is the financial challenges. These concerns extend to the financial future of HEIs such as considerable financial instability, both in the form of unexpected costs and potential reductions in revenue, i.e. owing to cancelation of enrollment of both domestic and international students and refunds on fees, room and board and the need to scale virtual engagement modalities (The NCSL Podcast, 2020; Rosowsky, 2020). The global economic recession puts a great impact on the HEIs' financial management and operation. To survive in these difficult times, leadership will need to prepare for numerous possible scenarios, seek creative solutions and stay flexible in the face of continuous change (Deloitte, 2020).

2.2 Overview of emergency preparedness/management plans in higher educational institutions

Most, if not all, universities develop guidelines that detail how to prepare for and respond to emergencies in the form of "Emergency Management Plan (EMP)," "Emergency Response Plan," "Crisis Management Plan," "Business Continuity Plan (BCP)" and others; however, the key information included in these plans have common elements.

The major part of most documents consists of a description of the roles and responsibilities of specific offices, departments and divisions and the structure of the incident command mechanism for emergency responses. In addition, some EMP also include a summary of the risk assessment and mitigation strategies. Most of the plans have two approaches in common: an all-hazard approach and four phases of emergency management, namely, preparedness, response, recovery and mitigation (University of Sydney, 2016; University of Auckland, 2013; University of Houston, 2020).

In these plans, emergencies are considered events that can cause death or significant injuries to staff, students, or the public. No further detailed definition is included on the types of incident categories (University of Auckland, 2013), nor on which incidents can suspend business, disrupt operations, create significant physical or environmental damage, or threaten the university's financial standing or public image (University of Otago, 2018). In principle, different types of hazards such as natural, biological, technological chemical, man-made attacks are the targets of an emergency/crisis management plan. However, depending on the type of frequent hazards in each country, their emergency management could have a different focus.

Because of the unique circumstances of university campuses, no one plan fits all templates applicable to all educational institutions. Campuses have to develop an individualized plan based on the specific threats and vulnerabilities that they face Kapucu and Khosa (2013). However, Zdiarski *et al.* (2007) provide guidance on a possible common template that includes the following:

- clear lines of authority that create a hierarchy of roles that lead to the campus president;
- action steps that give campus officials the roadmap of what to do depending on the nature of a crisis;
- established communication methods including a communications center that will ensure effective information exchange; and

- a clarified role for campus security and outside agencies and planning for business resumption such as a detailed continuity of operations plan, which will help to restore operations.

For HEIs, it is crucial to consider continuity of campus operations such as teaching, research and other auxiliary services and develop a BCP. As suggested by Zdiarski, a BCP is ideally a part of the management plan. Some universities have documents called “Emergency Management/Response and Business Continuity Plan” (Lamar State College, 2013; Pace University, 2014); however, many universities have a BCP that is separate from an EMP.

The intended purpose of BCP is to ensure business continuity, that is, to provide a detailed methodology governing how business is restored after a disaster, including for local incidents such as building fires, regional incidents such as earthquakes or national incidents such as pandemic illnesses (San Jose State University, 2020). Alternatively, some BCPs include the basic policy and procedures for initial response, business recovery and campus reopening in the event the university encounters a situation in which continuation of business activities becomes difficult (Waseda University, 2019). One of the characteristics of a BCP is that its development is often a responsibility for each department, and universities provide the template for a BCP document (Pace University, 2014; California State University, Los Angeles, 2019). Most BCPs are developed by academic departments or divisions and not by universities.

To conduct further research on a BCP or an EMP, the limitation and challenge is that not all the documents are open to the public, or some of them were written in the local language and English translated copy is not available; therefore, it is not easy to find these in an online search. At a result, it is extremely challenging to perform a detailed and specific analysis of the prevalence of an emergency plan and BCP in general in higher education settings.

A BCP and an EMP often take an all-hazards approach; however, some have focused on particular areas. The EMP developed by the University of Otago (2018) in New Zealand particularly includes a section of special provisions relating to pandemics/epidemics. The section consists of the following:

- a pandemic planned response; and
- pandemic communications.

Furthermore, a more specific BCP is dedicated only to pandemics. The pandemic influenza BCP of Massey University (2009) states that the motivation and reason for developing such a BCP is that the risk of an influenza pandemic is high, and the pandemic is certain to occur.

The document has also indicated that “social distancing” serves as one of the “containment activities” through people avoiding face to face meetings and classes; using virtual meetings/classes and conference calls; avoiding unnecessary travel and canceling or postponing non-essential meetings; studying/working from home or flexible hours; and avoiding all public transport. The reality is that many faculty and students are finding it difficult to adjust to the shift of the mode of education delivery, as it has never been expected; however, the university has already warned that these are the activities to be taken in case of pandemic.

California State University, Los Angeles (2019) has developed a pandemic BCP because pandemics can last long, can occur in the form of multiple events or waves and can disrupt every phase of every one’s lives – goods, services and transportation are all affected by delays to total shutdown. Therefore, the impact on universities will be enormous unless they are well prepared. The plan also suggests “Alternative methods to deliver services and classes” assuming the teaching system needs to be changed. As an alternative, it recommends using the learning management system for the courses, which is a type of e-learning.

One of the obvious post COVID-19 phase work should be to initiate a comprehensive review of BCPs/EMPs to get a realistic understanding of what worked and what did not and how current practices could be improved. If they worked, it might be asked whether each university should develop a BCP/EMP that focuses on different hazards/disaster types such as biological, chemical and natural disasters, or whether an all-hazards approach would be sufficient to cover different types of hazards.

2.3 Initiatives for creating a safe campus

To understand the level of disaster preparedness on campus including the existence of a disaster management plan at the university level, a survey was conducted in 2015 by the Association of Pacific Rim Universities (APRU) Multi-Hazards (MH) program. APRU is a network of 55 universities from 19 APEC economies in the Pacific Rim. Under the APRU, the MH program was established in 2013 and is led by Tohoku University in Japan. One of the major program activities is to support universities' disaster preparedness by conducting a survey and research on campus safety and organizing a biennial workshop.

The survey focused preparedness only for natural hazards. The survey showed only 45% of the respondent universities conducted a risk assessment, and out of the 45%, only 36% used the result of the risk assessment to discuss how to strengthen their risk management and/or mitigation strategies. Risk assessment and related information sharing were addressed as the biggest shortcoming on campus safety issues, and the major challenges were the lack of collaboration in universities, budget, awareness and human resources to enhance the disaster preparedness capacity on campus (APRU, 2015).

Even among the APRU member universities, conducting a risk assessment and sharing information targeting natural hazards was one of the challenges. If so, the risk assessment for all hazards could be a significant burden for universities. However, the concept of an "all-hazards approach" has been advocated for many years especially in the USA and Europe (Baucher *et al.*, 2018; FEMA, 1996). The need for this approach in Asia, which is the most disaster-prone area in the world will be high; however, the implementation level is still low. In the post COVID-19 phase, universities in Asia must seriously mainstream disaster risk management in their strategic and operational planning.

3. Covid-19 impacts on higher educational institutes

This study aims to understand the key challenges being faced by the HEIs around the world during the ongoing COVID-19 pandemic. The major findings of this study are derived from data collected with an online questionnaire survey that was conducted during April 10–27, 2020. The questionnaire was widely circulated among universities and research institutions through reliable networks such as APRU, the Integrated Research on Disaster Risk, the UN Office for Disaster Risk Reduction and the Asian Universities Network and was answered by 150 people from 65 universities, located in 29 countries, who belong to teaching and research professionals. This was specifically significant for the Asian universities, most of which have a semester starting from April. Thus, the initial challenges for the start of the seminars were captured properly.

3.1 Research methodology

A mixed research method combining qualitative and quantitative data was used to collate data. The process is as described below:

- The first step aims to understand the organizational preparedness and response. toward this end, information about disaster management and/or business continuity planning alongside the operational aspects and roles of disaster/emergency management unit or sections were sought from HEIs. Organizational response was collated through specific questions about response guidance, information sharing and decision-making in the HEI's in relation to COVID-19. Tables 1 and 2 provide details of the questions asked. The analysis was made at the organizational level based on the number of universities, not number of respondents. This is because, in some cases, there was more than one respondent from a specific institution. In case where multiple responses were received from one university, it was counted as one response only if all the responses are the same. In case where the answers are different, the responses were not analyzed.
- The second step was to ascertain if there is a relationship between organizational preparedness and the organizational response determinants. The study results (Yes/No coded to 1/0) were analyzed using a Peraman's correlation matrix that was developed using the IBM SPSS statistical software platform, The Speraman's correlation technique was specifically selected owing to the nominal data (Yes/No) derived from the study.
- The third step aimed to derive the key preparedness lessons and make recommendations for future pandemics and biological hazards based on the response activities taken at the organizational and personal levels and the challenges experienced COVID 19. Table 3 highlights the survey questions created for these purposes.

3.2 Key results and observations

A total of 150 responses from more than 65 universities located in 29 countries were received for the online survey. Majority of responses (75%) received were from the Asian region. The

Table 1. Questions to assess the organizational preparedness

S.No.	Key determinant and question	Scale
1	Emergency management unit: Does the emergency management office exist permanently in your university?	Yes/No
2	Business continuity planning: Has your university had a general BCP to prepare for an emergency?	Yes/No
	(a) If yes, does this BCP also target a biological hazard/pandemic?	Yes/No
	(b) If yes, has the simulation exercise been conducted in advance?	Yes/No

Table 2. Questions to assess the organizational response to COVID-19

S.No.	Key determinant and question	Scale
1	Response guidance: Was the response guidance and instruction communicated quickly from the HQ to faculty and staff?	Yes/No
2	Information sharing: Was the information sharing in university open and smooth enough?	Yes/No
3	Decision-making: Was the decision-making process regarding change in academic activities timely?	Yes/No

survey respondents represent a mixed gender composition, including both teaching and research staff from public and private universities. Close to half of the respondents reported having added management and outreach responsibilities owing to the pandemic. The quality of study (risk perception) results were affirmed as majority of the survey respondents (68%) have more than ten years of experience in higher education institutions. In other words, majority of the respondents have provided higher education and/or conducted research under different types of HEI leadership as well as local, regional and national regimes.

3.2.1 University-level analysis of organizational preparedness and response to COVID-19. Ninety-three of the 150 survey respondents disclosed the names of their universities/HEIs. After filtering the multiple responses from the same university and omitting the discrepant responses (process explained in subsection 3.1), the unique data of 51 universities from 22 countries was used to assess the organizational preparedness and response determinants.

3.2.1.1 Organizational preparedness. Figure 1 shows that 47% of respondents with defined universities believe their institutions lacked a permanent or dedicated emergency management office, and 41% said their HEIs lacked a general business continuity plan for an emergency. This shows that closed to half of the responding universities have not developed BCP yet. As such a key preparedness plan is crucial to maintaining safety on campus, the situation has to be fixed urgently.

Key determinant	Research question
Response activities at the organizational level	What kind of response activities were taken by your university against COVID-19? *(multiple choice question)*
Identified challenges at the organizational level	What kind of challenges did you find in your university's preparedness and response? *(multiple choice question/top 3)*
Preparedness lessons at the organizational level	Based on your experience, what kind of preparedness measures would you recommend for the University in future? *(Short text answer)*
Responses activities at the personal level	What were your personal response activities against COVID-19 pandemic? *(multiple choice question/top 3)*
Identified challenges at the personal level	If you switched over to online teaching, what were the key challenges? *(multiple choice question/top 3)*
Preparedness lessons at the personal level	If you can bring one key lesson from the pandemic for your future professional preparation, what would be that? *(short text answer)*

Table 3. Questions to assess the COVID-19 response activities and challenges

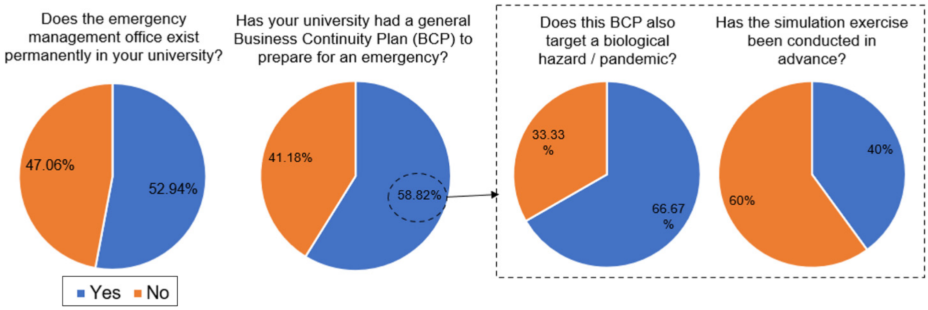

Figure 1. Organizational preparedness determinants for the 51 defined universities

In universities with BCPs, 33% of the plans do not cover biological hazards and pandemic risk management, and 60% of the plans did not include conducting any advanced simulation exercises. Based on these reported figures, it can be deduced that several organizations were not prepared for a global pandemic such as COVID-19. While many universities did not have a permanent emergency management office or business continuity plan in place, there was also very limited focus on biological hazards and advanced simulation exercises.

3.2.1.2 Organizational response. In relation to the organizational response determinants, Figure 2 shows that more than 70% of the respondents said the instruction, information sharing and decision-making processes were timely and open. However, 30% of the respondents said their HEIs need to urgently improve in these areas. It is assumed that with better plans and resources such as BCPs and EMUs, more universities can potentially make faster and effective responses to global scale disasters including pandemics. In total, 67% of the universities that did not have BCPs said instructions were communicated quickly enough but the information sharing process was not open and smooth enough.

3.2.1.3 Correlation analysis. Spearman's correlation matrix was used to analyze the strength of association (significance levels of co-relation) between the defined determinants of organizational preparedness and response. It is important to note that the values in Spearman's correlation always range from "−1" to "1" with a value close to the extreme ends denoting stronger association. Also, as the correlation matrix is symmetrical, the values above the diagonal will have the same values as below. The positive significance values of co-relation denote a positive relationship among all the concerned determinants. That is, if the response for one of them is "Yes," the other determinants have a high probability of being "Yes" too.

Table 4 shows that the highest significance levels of co-relation below the diagonal (0.70) indicates that the determinants of "Smooth Information Sharing" and:

> Timely Decision making are strongly associated. Further, it shows that the presence of a BCP and permanent EMU in universities is positively associated with all the response determinants of 'Quick Response Guidance' and 'Smooth Information Sharing'

Notably, the relationship between BCP and the organizational response determinants is stronger that with the EMU. The study found that a pre-determined BCP, and an established EMU in a university can considerably enhance the organizational response to hazards such as COVID-19. The strong relationship among the three organizational response determinants is clear from their high correlation values (0.53, 0.43 and 0.70), which

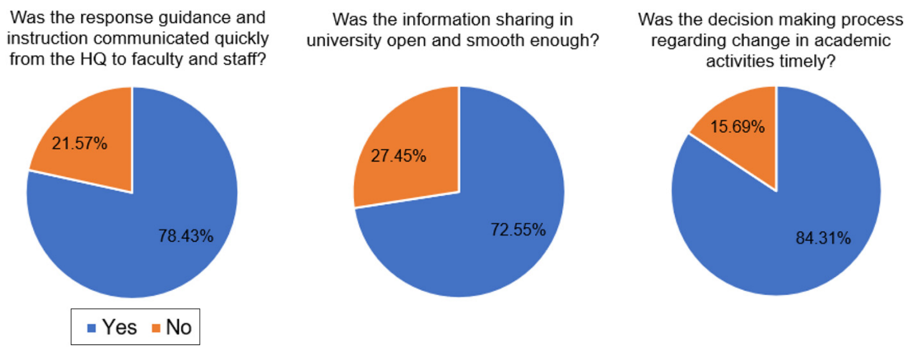

Figure 2. Organizational response determinants for the 51 defined universities

underscore the strong link between them (quick response guidance and instruction may lead to smooth information sharing).

3.2.2 Individual-based analysis of COVID-19 university response activities, challenges and key lessons.

3.2.2.1 Types of organizational responses. Figure 3 highlights the COVID-19 response activities carried out by the universities. It shows that majority of the respondents reported that the physical locations of the HEIs are affiliated with are temporarily closed down tuition is now through online classes. In addition to tweaking the academic calendar, several universities have reportedly extended support to their immediate communities and local governments. This is in the form of technical assistance such as modeling and forecasting and health-care support such as production of personal protective equipment and hand sanitizers and data sharing. In the "Others" category, the respondents provided additional response activities at the organizational level. These support activities range from converting university hostels into quarantine centers, to fundraising campaigns, volunteer services, financial and psychological support to stranded students, etc.

3.2.2.2 Key challenges at organizational level. The respondents were asked to select three key challenges that their HEIs have had to face during the COVID-19 pandemic (Figure 4). The major challenges identified were a lack of adequate preparedness for a pandemic and of pandemic-specific advanced simulation exercises. The study found that half of the responding universities did not have BCPs and EMUs, which correlates with the results from questions on organizational preparedness.

Determinant name	Emergency management unit	Business continuity planning	Quick response guidance	Smooth information sharing	Timely decision-making
Emergency management unit	1	–	–	–	–
Business continuity planning	0.57	1	–	–	–
Quick response guidance	0.27	0.34	1	–	–
Smooth information sharing	0.21	0.47	0.53	1	–
Timely decision-making	0.03	0.19	0.43	0.7	1

Table 4. Spearman's correlation matrix for preparedness and response determinants

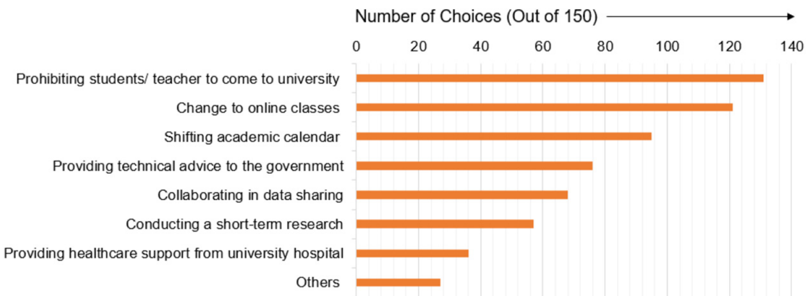

Figure 3. COVID-19 response activities at organizational level

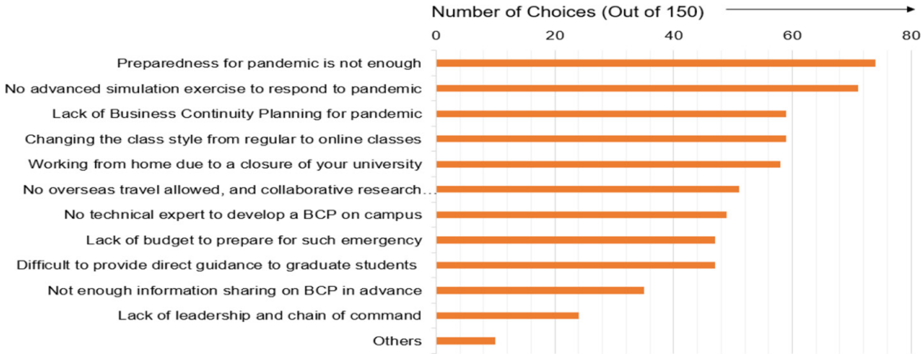

Figure 4.
Key challenges at organizational level

The other two challenges identified in the survey were the change in the mode of teaching to online lectures and working from home. Most HEIs have never experienced a global scale pandemic and making the shift from face-to-face classroom teaching to online teaching was a major change that posed a significant challenge for many HEIs. In particular, the course which has laboratory experiments and studio work, it was rather difficult to make the changes instantly. On the other hand, it also provided an opportunity for universities to invest in adopting an innovative educational system which can support teaching, interaction and discussion in multiple ways and modes. It is, therefore, unsurprising that in the "Others" category, the importance of strengthening internet access to students and teachers was highlighted.

3.2.2.3 Key lessons for future organizational preparedness. Seven recommendations for future organizational preparedness were made from the responses received:

- *Planning and familiarization for multiple educational method and tools*: there is a need to develop backup plans for meeting various academic requirements such as conducting end-of-term and thesis examinations, during emergency situations. It is extremely important to provide necessary support to students for internet-based teaching, discussions, educational systems and examination methods.
- *BCP*: to prepare for emergencies, a university-level and a faculty, graduate school, academic department level-BCP is required. The BCP should establish guidelines for switching to an online education delivery system, including the process, preparation, communication with students and providing necessary support to them.
- *Emergency management unit (EMU)*: A dedicated emergency management unit should be created in all HEIs. The mandates and responsibilities of the EMU should be communicated to all staff, faculty and students. EMUs should proactively conduct and lead simulation exercises at regular intervals on different scenarios that include biological hazards and ensure timely training and capacity building of task forces dedicated to such events at campus and department level.
- *Risk communication*: HEIs should conduct regular awareness programs on risks, preparedness and responses for staff, faculty and students. To realize this, a thorough risk assessment is crucial, and it should follow all hazard approaches. Currently, risk communication strategies at HEIs are framed around natural disasters and laboratory based fire/chemical safety risks. Potential biological

hazards, risks of sudden attack/mass shooting, riots, stampede, etc. should also be part of the risk communication strategy.

- *Blended learning approaches*: HEIs are urgently required to upskill in the use of online platforms/modes alongside classroom/fieldwork teaching. To regularize the blended approach, a fair share of lectures/classes every year/semester can be conducted online.
- *Networking*: to enable knowledge and information sharing during emergencies, universities should establish strong networks with local governments, other universities, the private sector, civil society organizations and communities. These partnerships will help to advance the risk reduction agenda not only at HEIs but in the larger system within which HEIs exist.
- *Designated funding*: universities should set aside reasonable designated funds to boost research and innovation against all forms of hazards. In addition, they need to plan for tough times when disasters have widespread impact on all sectors of the economy.

3.2.2.4 Personal responses to COVID-19. Figure 5 highlights a wide range of personal response activities carried out by respondents in response to COVID-19. It shows that majority of the respondents have been giving online classes while working from home. This means the respondents have spent considerably more time getting used to providing online lectures, attending online courses and webinars while also managing routine academic administration and research activities. This leaves little time for conducting additional activities such as community services or even shopping for their routine needs. Moreover, owing to the nature of coronavirus disease and its mode of contraction, the assistance provided in the form of community service remains extremely limited.

3.2.2.5 Personal challenges in online teaching. Figure 6 highlights the key challenges reportedly being faced by the respondents in switching to online delivery of lectures. Majority of the respondents identified conducting group works, technical difficulties (such as slow internet speed, unstable internet connection, etc.) and maintaining student motivation (because students are used to studying in a classroom environment) as the top three challenges they face. The further pointed out that group discussions and assignments are difficult to effectively conduct in online environment. This was identified as major disadvantage for both students and faculty.

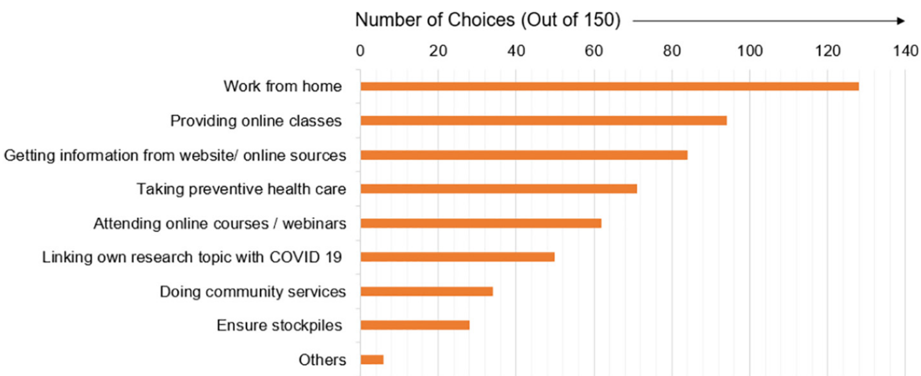

Figure 5.
COVID-19 response activities at personal level

3.2.2.6 Key lessons from COVID 19: Academic/research continuation on future pandemics. Key lessons for better preparedness for future disasters were identified by the respondents through short descriptive answers. They are summarized as follows:

- *Personal safety*: there is a dire need for everyone to take adequate precautions and safety measures such as wearing masks, optimal personal hygiene and maintaining physical distance to prevent infections. It is important to rely on authentic sources of information, rather than social media posts which are often half baked or exaggerated.
- *Raising awareness on epidemics and pandemics*: every academic faculty and administrative staff at HEIs should get training on adequate and up-to-date awareness on safeguards against biological hazards. It is common to have knowledge of local natural hazards, but one must not forget that "disasters" and "risks" can also be from non-natural and human-induced hazards.
- *Wider range of teaching methodology and tools*: It is important for every HEI to promote and effectively provide resources for teaching by exploring the immense power of internet. It was recommended that universities provide suitable exposure and training to faculty, staff and students and also help them with reasonable resources to learn effectively through Web-based teaching methods. It is also crucial that the homes of faculty and students alike are equipped with stable and high-speed internet connection for smooth application of various methods.
- *Research and innovation*: COVID-19 has triggered an urgent need to invent alternatives to the conventional classroom-based teaching methods. Laboratory-based research has certainly been hit hard owing to restricted movement within and outside university campuses and social distancing rules that make it hard to conduct lab-based research in collaborative teams.

4. Key immediate and long-term mitigation measures

The survey results show that many universities do not have BCPs or, in cases where a BCP exists, have not conducted simulation exercises for a pandemic scenario. Further, at the organizational level, in most HEIs, the faculty, staff and students face significant difficulties in adjusting to the switch to online delivery of classes. This is because of technical issues such as a lack of strong internet connectivity, unfamiliarity with online classroom/conference platforms and inability to use different approaches to teaching and learning such as group work and discussions.

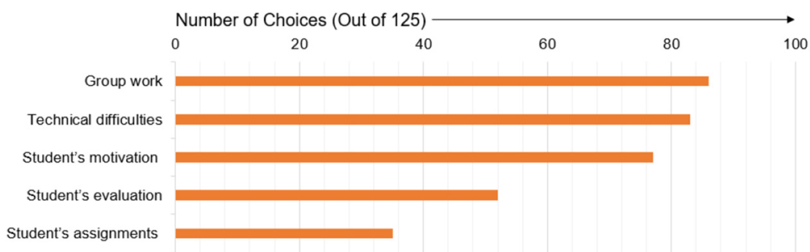

Figure 6.
Identified personal-level key challenges of online teaching

As a positive side, the survey also showed that universities have been working actively with local governments and other partners by sharing data and providing technical advice. Thus, universities are expected to play a crucial role and contribute to society.

Based on the survey findings, the following recommendations are expected to strengthen the current disaster preparedness capacity in HEIs.

4.1 Governance/planning (short term)

A planning document such as an emergency management plan/BCP provides the foundation for risk management. It is crucial to develop a plan based on capacity, vulnerability and needs assessment and to identify clearly what needs to be done in each stage to manage a disaster and ensure safety on campus. This includes establishing an incident command system for emergencies and conducting regular mock exercises, drills and simulations to test the plan and determine its effectiveness (APRU, 2015). While developing a campus emergency plan, it is important to make it an adaptable document that can address a variety of emerging hazards and that provides strategies and practical approaches to tackle different types of disasters.

In addition, universities urgently need to consider carrying out simulation exercises and making it a regular disaster preparedness activity. The simulation exercise must take different scenarios including pandemics into account because responses may differ from disaster to disaster.

4.2 Infrastructure/educational system (short term)

The lessons learned from the current pandemic that are addressed in the survey include the need to adopt a new and innovative educational system. This requires both technical support in the form of training and financial support with investment in high-speed and stable internet connectivity not only on campus but also at home. Furthermore, it is crucial to include clearly stated guidelines in a BCP on the procedure to be followed for making changes while conducting crucial ceremonies and activities such as graduations, commencement ceremonies and examinations.

4.3 Physical/mental health

A sizeable portion of students live in the university dormitories and rented accommodations. Owing to strict lockdown in many countries, the students experienced high level of stress. Many students also experienced financial stress and were unable to pay rent, utility bills or internet as many students' support from family also dried because, at times, family members also lost jobs. Owing to lack of planned approach and inexperience to work from home, many felt that their functionality is impacted. On the contrary, a sizeable number of people also reported that they were more productive while working from home and some felt that their workload is increased after the pandemic related restrictions are implemented.

4.4 Reopening of campuses

There is a big uncertainty around re-opening of university campuses. In many university campuses, classroom or face-to-face teaching is completely stopped until July 2020 or later. In addition, a number of universities have shifted the dates of their entrance/final exam and of semester start/finish without further notice of new dates of conducting these activities. Senior high-school students and final year university students are facing unique situation owing to ongoing restrictions around organizing welcome/orientation/graduation ceremonies. Current students are also going through anxiety owing to uncertainty around campus reopening dates and many are considering to return to their families to save on rents and other expenses.

5. Conclusion

Most universities do not have experience dealing with a pandemic such as COVID-19, unlike responding to natural disasters. Therefore, this is their first significant experience with changing the styles, systems and methodologies of education, research and contributing to society. This sends a clear message regarding the necessity to prepare for both frequent disasters and unfamiliar ones such as chemical, technological and biological disasters that take a heavy toll. The most important elements for creating a disaster-resilient university are developing an all-hazard plan, conducting regular trainings and exercises, developing strong community partnerships (Kapucu and Khosa, 2013) and taking innovative approaches to education and research.

Universities in English-speaking countries are facing a rather unique challenge of loss of income. However, they possess a rich experience of providing online classes. Therefore, this is the time to promote north–south collaboration among universities continue to generate, distribute and share knowledge even when a pandemic such as COVID-19 disrupts the world order.

This study has helped to better understand challenges faced by and opportunities available to HEIs. HEIs will have to consider post-COVID-19 scenarios seriously and how they can remain relevant to their students and the society at large. Internet-based teaching is relatively new for most universities in Asia, and to some extent, is forced. However, this also opens a dialogue to prove the effectiveness of HEIs in creating a knowledge society. Beyond digital technologies, HEIs need to reposition themselves to augment the skills needed to prepare a workforce that is better prepared to respond to future disasters of a similar scale.

References

APRU (2015), "APRU-IRIDeS Multi-Hazards program: campus safety report 2015", available at: http://aprumh.irides.tohoku.ac.jp/app-def/S-102/apru/wp-content/themes/APRU-IRIDeS/img/page/MHPCSR2015.pdf, (accessed on 1 April 2020).

Bao, W. (2020), "COVID-19 and online teaching in higher education: a case study of Peking University", *Human Behavior and Emerging Technologies*, Vol. 2 No. 2, doi: 10.1002/hbe2.191.

Baucher, A. Kearns, P. Gyenes, Z. Heraty, W. Baubion, C. Gamper, G. and Guzman, O. (2018), "Towards an All-Hazards approach to emergency preparedness and response. Lessons learnt from non-nuclear events (NO. NEA 7308) OECD",

California State University, Los Angeles (2019) "Pandemic business continuity plan", available at: www.calstatela.edu/sites/default/files/groups/Environmental%20Health%20and%20Safety/pandemic_master_april_2019.pdf. (accessed on 7 May 2020).

De Oliveira Araujo, F., De Lima, L., Cidade, P., Nobre, C. and Neto, M. (2020), "Impact of Sars-Cov-2 and its reverberation in global higher education and mental health", *Psychiatry Research*, Vol. 288, doi: 10.1016/j.psychres.2020.112977.

Deloitte (2020), "COVID-19's impact on higher education: strategies for tackling the financial challenges facing colleges and universities", available at: https://www2.deloitte.com/content/dam/Deloitte/

us/Documents/public-sector/us-gps-covid-19-impact-on-higher-education.pdf. (accessed on 14 June).

Federal Emergency Management Agency (1996), "Guide for All-Hazards emergency operations planning", Retrieved from www.fema.gov/pdf/plan/slg101.pdf

Hua, J. and Shaw, R. (2020), "Corona virus (COVID-19) 'infodemic' and emerging issues through a data lens: the case of China", *International Journal of Environmental Research and Public Health*, Vol. 17 No. 7, p. 2309, doi: 10.3390/ijerph17072309.

Kapucu, N. and Khosa, S. (2013), "Disaster resiliency and culture of preparedness for university and college campuses", *Administration and Society*, Vol. 45 No. 1, doi: 10.1177/0095399712471626.

Lall, S. and Singh, N. (2020), "COVID-19: Unmasking the new face of education", *International Journal of Research in Pharmaceutical Sciences (SPL)*, No. 1, pp. 48-53.

Lamar State College (2013), "Emergency management and business continuity plan", availbale at: www.lsco.edu/finance/EMBC-Plan.pdf. (accessed on 15 May 2020).

Massey University (2009) "Pandemic influenza business continuity plan (a subset of the University crisis management plan)", available at: www.massey.ac.nz/massey/fms/About%20Massey/Risk%20Management/Documents/Pandemic%20Influenza%20Business%20Continuity%20Plan%20v2.pdf. (accessed on 10 May 2020).

Pace University (2014), "Emergency response and business continuity plan", available at: www.pace.edu/sites/default/files/files/emergency-response-and-business-continuity-plan.pdf, (accessed on 10 May 2020).

Rosowsky, D. (2020), "Four ways COVID-19 is hurting higher education and why that matters", available at: www.forbes.com/sites/davidrosowsky/2020/05/04/four-ways-covid-19-is-hurting-higher-education-and-why-that-matters/#63c2c9b459f1. (accessed on 14 June).

San Jose State University (2020), "Business continuity planning (BCP)", availbale at: www.sjsu.edu/adminfinance/docs/BCP_Master_Plan.pdf. (accessed on 10 May 2020).

Shaw, R., Kim, Y.K. and Hua, J. (2020), "Governance, technology and citizen behavior in pandemic: Lessons from COVID-19 in east Asia, in progress in disaster science", *Progress in Disaster Science*, Vol. 6, doi: 10.1016/j.pdisas.2020.100090.

Tan, A. (2020), "Zoom is your new classroom: Will online education become the norm after COVID-19?", Accessed from www.msn.com/en-my/news/other/zoom-is-your-new-classroom-will-online-education-become-the-norm-after-covid-19/ar-BB15myku Accessed on 14 June 2020.

The Guardian (2020), "UK universities face cash black hole amid coronavirus crisis", availbale at: www.theguardian.com/education/2020/mar/06/uk-universities-face-cash-black-hole-coronavirus-crisis. accessed on 14 June 2020.

The NCSL Podcast (2020), "Higher education responses to coronavirus (COVID-19)", Accessed from www.ncsl.org/research/education/higher-education-responses-to-coronavirus-covid-19.aspx Accessed on 14 June 2020.

University of Auckland (2013), "Crisis management plan", Accessed from https://cdn.auckland.ac.nz/assets/central/about/the-university/how-the-university-works/policy-and-administration/university-of-auckland-crisis-management-plan.pdf, (accessed on 7 May 2020).

University of Houston (2020), "Continuity of operations plan", Accessed from www.uhd.edu/administration/emergency-management/Documents/2017%2011%2015%20University%20of%20Houston%20Downtown%20COOP.pdf, (accessed on 10 May 2020).

University of Otago (2018) "Emergency management plan", Accessed from www.otago.ac.nz/administration/policies/otago689752.pdf, (accessed on 10 May 2020).

University of Sydney (2016), "University emergency response plan", Accessed from www.sydney.edu.au/content/dam/corporate/documents/about-us/campuses/university-of-sydney-emergency-response-plan.pdf. (accessed on 10 May 2020).

Waseda University (2019), "Waseda university BCP", Accessed from www.waseda.jp/top/assets/uploads/2019/04/Waseda-University-BCP-First-Edition_Public-version.pdf, (accessed on 10 May 2020).

WHO (2020), COVID 19 Public health emergency of international concern: global research.

Zdiarski, E., Dunkel, N.W., Rollo, J.M., *et al.* (2007), *Campus Crisis Management: A Comprehensive Guide to Planning, Prevention, Response and Recovery*, San Francisco, CA: Jossey-Bass.

Further reading

Djlante, R., Shaw, R. and DeWit, A. (2020), "Building resilience against biological hazards and pandemics: COVID-19 and its implications for the Sendai framework, in ", *Progress in Disaster Science*, Vol. 6, doi: 10.1016/j.pdisas.2020.100080.

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Governance, technology and citizen behavior in pandemic: Lessons from COVID-19 in East Asia

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ABSTRACT

Corona Virus (CODID-19) was first reported in Wuhan in December 2019, then spread in different parts of China, and gradually became a global pandemic in March 2020. While the death toll is still increasing, the epicenter of casualty has shifted from Asia to Europe, and that of the affected people has shifted to USA. This paper analyzes the responses in East Asian countries, in China, Japan and South Korea, and provides some commonalities and lessons. While countries have different governance mechanism, it was found that a few governance decisions in respective countries made a difference, along with strong community solidarity and community behavior. Extensive use of emerging technologies is made along with medical/health care treatment to make the response more effective and reduce the risk of the spread of the disease. Although the pandemic was a global one, its responses were local, depending on the local governance, socio-economic and cultural context.

1. Introduction

It is now widely acknowledged that the Corona virus (COVID-19, as formally known) was first reported in Wuhan, China in December 2019, and was recognized by Chinese authorities as a new virus in January 2020. WHO (World Health Organization) declared this as a PHEIC (Public Health Emergency of International Concern) in the end of January 2020. After the initial delay in the source point (Wuhan), Chinese authorities took utmost efforts to control the spread of the disease, however, it has already started impacting other parts of China as well as other countries during mid to end of January. A term "infodemic" has been used by the WHO Director General at the initial stage of the spread of the disease (during mid-January 2020: [1] in Lancet), which seems to be still valid while writing the paper in the end of March 2020. WHO colleagues have warned the tsunami of information, especially with social media, which many times call for panic situation. We have observed this in several countries, as well as fake news spreading through social media. On 11th of March 2020, WHO has declared this as a global pandemic, and as of 23rd of March 2020, the virus has affected 172 out of 195 countries.

While the statistics of infected people, casualties changing rapidly overtime, it is very difficult to put a number. As of 29th of March, there are more than 30,000 death reported, while more than 23,000 people are in critical conditions globally. More than 650,000 people are affected. Although it is early to make any comment on the nature of its spread, a few characteristics can define this new virus as follow:

- **High rate of spread**: Within three months the virus has spread globally and is considered as a global pandemic. The rate of its spread is high, which happened due to higher mobility of people in a globally interconnected world. It can be said that people to people transmission rate of very high.
- **Aged and low immune people more vulnerable**: Data shows that the aged population [2] and people with low immunity (with diabetes or other chronic disease) are more vulnerable to this virus.
- **Differential recovery rate**: While the global average of recovery rate is relatively low (like 28 to 30%), different countries have differential recovery rate. While China, Korea, Japan has relatively high recovery rate, Europe, Iran, USA showed relatively lower recovery rate. Of course, this is constantly changing, and hopefully gets better soon.

Over last few weeks, there are several words which got significant attention like: "community spreading", "social distancing (physical distancing)", "self-isolation", "14 days quarantine", "lockdown," "break the chain" etc. All these are used for one purpose, which is to stop spreading the virus. Although there are reported use of medicines from different countries (without proper confirmation); there is no confirmed medicines used to cure this virus, or no vaccine available for COVID-19 as of March 23, 2020. Thus, the only way to stop the spread is to isolate us from social gathering or masses, and isolate confirmed people for quarantine. This process needs a combination of strong governance, use of existing and next technologies in innovative ways, and strong community participation and solidarity. Anderson et al. [3] made interesting analysis on how the country-based mitigation measures influence the course of epidemic (while they wrote the paper, the COVID-19 status was not a pandemic).

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While acknowledging that governance, citizen participation/awareness, penetration of technology varies from country to country, this paper makes a modest effort to analyze the experiences of China, Japan and Korea as East Asian cluster. Time series analysis of the key governance decision is made and its correlation with the spread of the virus within these three countries are observed. A few common lessons are drawn, which have larger implications to the society in this critical phase of COVID-19 global pandemic.

2. Global chronology of COVID-19

WHO Beijing office got the first information of an unknown virus on 31st of December 2019. From that point, three months are passed. In this section, a few global measures (mainly excluding East Asia, which will be described later), especially the role of WHO is narrated. Within two weeks from the first report in WHO Beijing office, first overseas case was reported in Thailand on 13th of January 2020. WHO Director General met Chinese President on 28th January and declared it as PHEIC (Public Health Emergency of International Concern) on 30th January. On the following day, Italy declared a national emergency with two case reported there. The virus spread continued in China as well as overseas after that, and on 11th February WHO has named the virus as COVID-19. A United Nations CMT (Crisis Management Team) was formed with WHO as the coordinating agency. WHO has appointed a few prominent persons as their COVID envoy on 21st of February to provide advices to different countries. A series of missions were organized by WHO team: one in Italy (24th February), one joint mission in China (25th February), and one in Iran (2nd March). 24th February was the time when the global epicenter has started shifting from China to other countries, with number of affected people outside China crossing that within China. Two major clusters were observed, apart from Kore and Japan: one in Iran and the other in Europe (northern Italy). Early March showed steady growth of affected people globally. WHO declared its research road map on 6th of March, and on 7th of March, it was found that the virus has affected 100 countries, and more than 100,000 people. This prompted WHO to declare COVID-19 as a global pandemic on 11th of March, and USA declared national emergency on 13th of March. Fig. 1 shows the number of affected people globally with key WHO decisions stated above.

The above description shows that within two months (from 13th of January, when first case was reported in Thailand, outside China to 13th of March, when USA declared emergency), the virus has taken a significant number of lives, affected a large number of people, and brought down many countries, including the economic hubs under lockdown. Several countries have made travel bans, lock down of cities and provinces, which has also impacted significantly the local as well as global economy.

As of 27th February 2020, a report by Mckinsey [6] has identified six global clusters as follow: Mature propagation (china complex), Early propagation (East Asia and Middle East complex), New propagation (Western Europe), and No propagation (Africa and America complex). However, one month has changed the scenario, where Western Europe complex has become the new epicenter, and America has observed a significant propagation. Based on the simulation, Mckinsey [6] proposed three global scenarios of quick recovery, global slowdown and global pandemic and recession. This would affect differentially the second and third quarter of the year. While the base scenario talks on the control of spread in East Asia in Europe in early second quarter, the early recovery predicts that it would be in late first quarter, while the recession/pandemic scenario talks about middle to late second quarter.

3. Chronology of events in East Asia and key policy decisions

Fig. 2a shows a comparative analysis of total number of confirmed, recovered and death in China, Korea and Japan. Fig. 2b shows the same on daily increase in these three countries. In both of Figures, since the numbers in China exceeds that in Korea and Japan by a significant percentage, the values are provided to show the highest numbers in China. China sees a sharp increase in number of confirmed cases from the third week of January, while a sharp increase in both recovered and death from the first week of February. Korea saw a sharp increase in number of cases from third week of February, while Japan saw an increase in the first week of March.

3.1. China

Detailed time series analysis of China is presented in Hua and Shaw [7], where the responses have been divided into five phases: 1) very early phase (up to 31st of December 2019), 2) investigation phase (up to 20th of January 2020), 3) early intensification phase (up to 31st of January 2020, 4) criticism, agony and depression phase (up to 14th of February 2020) and 5) positive prevention and curative control phase

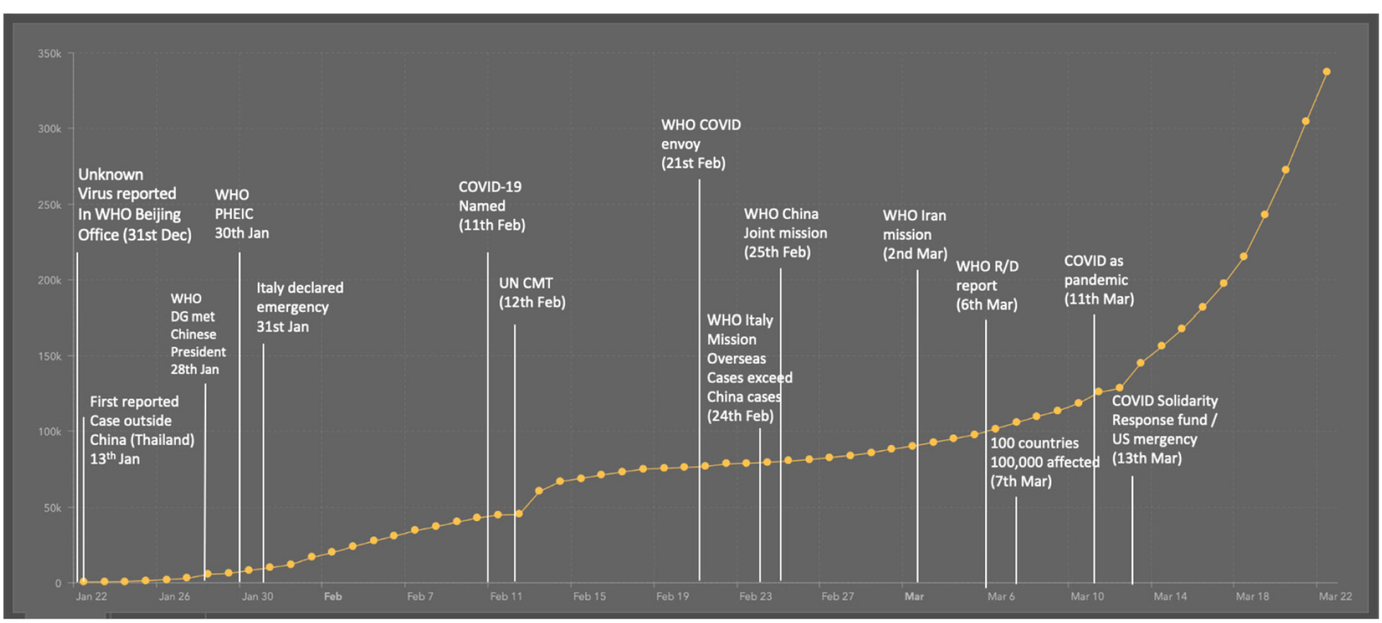

Fig. 1. Growth of globally affected COVID-19 affected people with key WHO decisions (drawn by authors with basic data from John Hopkins Corona virus Resource Center [4] with WHO rolling updates [5].

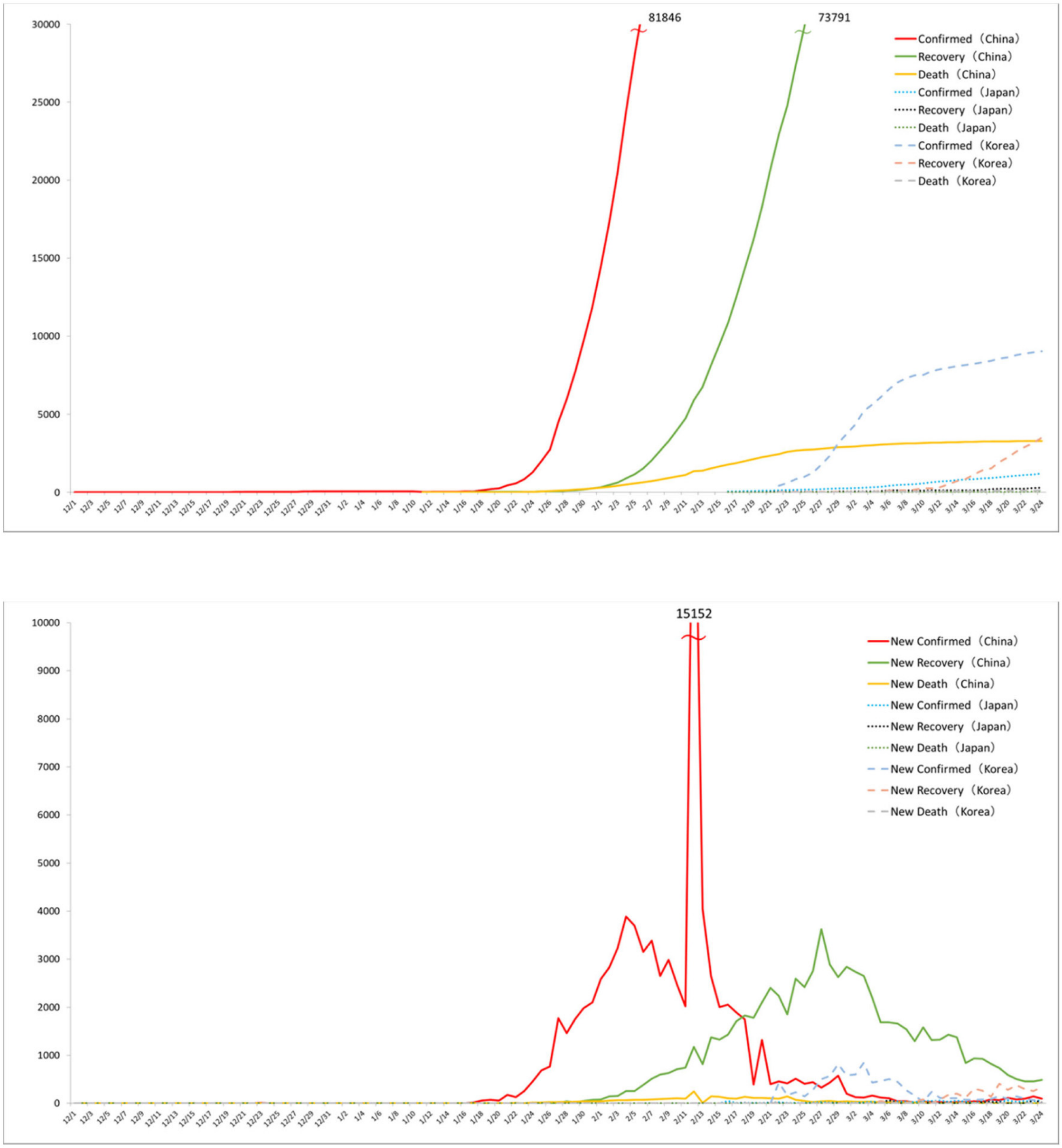

Fig. 2. a. Total number of confirmed, recovered and death in China, Korea and Japan. Panel b. Daily increase of confirmed, recovered and death in China, Korea and Japan.

(up to 29th February 2020). This paper also looks at the other events in March until 25th of March 2020. While looking at the key policy decisions taken over the course of action, a few clusters can be observed as follow (Fig. 3).

Cluster 1 (**20–25 January 2020**): On 20th January 2020, Dr. Zhong Nan Shan made official announcement in CCTV about the new type of virus identified in Wuhan, followed by announcement of emergency in Hubei province on 22nd of January, and decision on constructing new hospitals on 23rd and 25th of January. During this cluster the source area went under lockdown, and emergency response started officially. Based on these key decisions, emergency supplies including goods and medical teams arrived in Wuhan from different parts of the country.

Cluster 2 (**2–5 February 2020**): On 3rd of February 2020, city sanitization started with public spaces, parks etc. On 5th of February, a major decision was taken on “no one will be spared”, which enabled the government officials to enter into people's house and check virus symptoms. This was a key turning point to identify new cases of affected people. A sharp increase in the number is also observed as a result of policy decision taken in Cluster 1 and 2 (Fig. 3). To stop spread of the disease, it was important to identify all possible sources. Thus, the strict decisions taken in cluster 1 and 2 were crucial. QR code was introduced for all residents on February 18, and this was a good check to distinguish between the affected and non-affected people. The next couple of weeks were devoted to implement the policy decisions and be vigilant for its violation.

Cluster 3 (**10–13 March 2020**): Visit of President Xi Xinping to Wuhan was a key turning point of the epidemic, which sent a message that the disease spread was under control. On 11th of March, WHO declared COVID-19 as a global pandemic. On 13th of March, the city of Qianjiang city in Hubei province has opened its business for the first time since the lockdown. This was also another indicator that the situation within China is under control, with appropriate preventive and curative measures are placed.

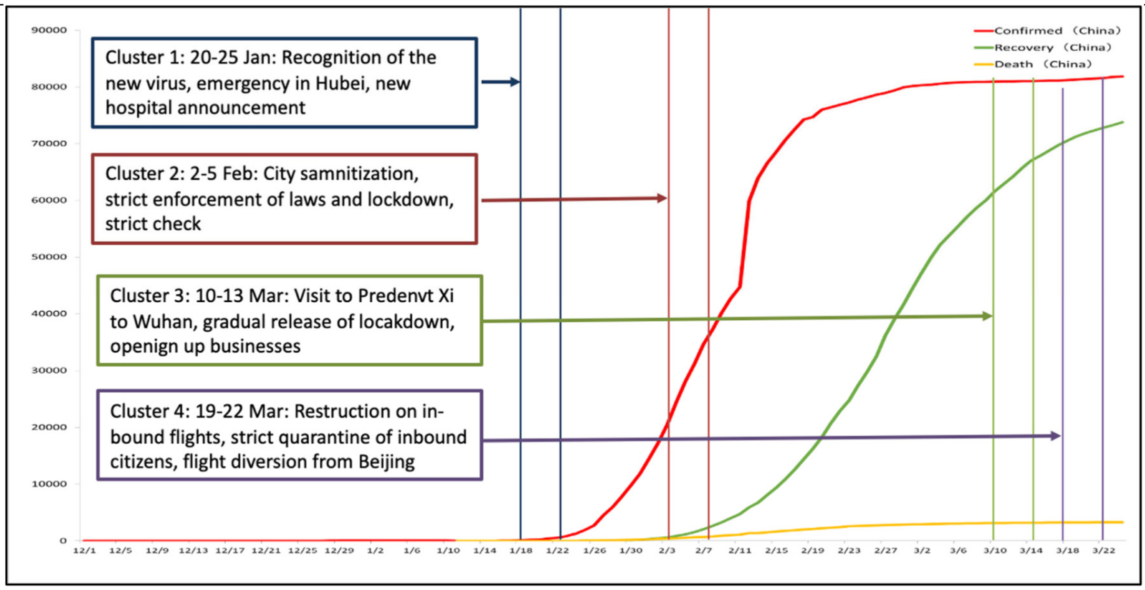

Fig. 3. Chronological changes and key policy decisions in China.
[Source: This figure was prepared by the authors using original data from: Sina, Tiki-Toki, Caixin, Baidu, see references].

Cluster 4 (19–22 March 2020): This cluster is characterized by the affected people arriving from overseas. The case of affected people entering the country from overseas was noticed on 6th of March 2020 reported in Shanghai and Shenzhen. This sent an alert to the Chinese authorities for the preparation of the returnees from overseas countries and urged stricter control on entry to the country. On 19th of March, in-bound flights to Beijing were advised to divert to other nearby airports aiming to reduce the burden to the capital city, and finally all overseas flights to Beijing was cancelled on 22nd of March. Selected hospitals were designated as specialized hospitals to treat the affected people, which other hospitals started sanitization. On 23rd of March, Wuhan lifted emergency and lockdown, however full normalization of life was aimed until 8th of April.

In case of Taiwan, the time series analysis points out an early preparation. As early as 31st of December 2019, Taiwan announced medical advisory (14 days self-vigilance, wearing mask, temperature check etc.) to inbound visitors on the Wuhan and started medical test. Specific warning was issues to all in-bound people from Wuhan on 6th of January, and was repeated four times (10th, 11th and 17th January). A team of experts was dispatched to Wuhan on 6th of January to identify the new disease spread. There was an early warning issued on restraining and legal actions on fake news spread, which was also repeated several times (11th, 17th, 21st and 23rd January). First confirmed case was reported on 21st January in Taiwan, which also prompted some other key decisions. To protect panic buying, the government bought masks, and started its own distribution system through national insurance card. Number of masks entitled per insurance card was strictly monitored, and masks were distributed free of charge in the rural areas. This system started at the early stage (3rd of February), and system was developed and customized based on the need and supply of masks, and finally the online shopping system started on 12th of March.

Other measures in Taiwan include: 1) introduction of health declaration card at entry points (airports and ports) on 11th February, 2) pre-entry electronic health declaration on 14th of February, 3) issuing travel advisory to mainland China (in January), Korea and Japan (on 22nd February), 4) provide special allowance to all medical staffs (from 23rd of February), 5) provide financial assistance to family of affected people (on 11th of March), and 6) provision of free medical treatment of the affected people not having medical insurance in Taiwan. The entry from Europe and middle east was restricted on 11th March, and total travel ban was announced on 19th of March to be effective from 24th of March to 7th of April. On 25th March, all night entertainment was banned, and gathering more than 100 people in one place was prohibited. Experience of Taiwan points out that an early level of risk identification, risk understanding and risk control and mitigation are key to prevent the spread of the disease. Prior experience of SARS may have been utilized to take early decision making, along with the inputs from the experts.

3.2. Japan

Japan reported the first case of COVID-19 between 10 and 15 January 2020 from a Chinese national who travelled from Wuhan. The second and third cases were reported on 24 and 25th January. It gradually spread through tourism industry (like bus driver, tour guide etc.). During 28th January to 17th February, Japan evacuated more than 800 Japanese national from Wuhan through five chartered flight. A detailed description of appearance of different cases in Japan can be found in Wiki [8]. Here, a few critical issues on Japan's approach is described below:

Diamond Princess Experiences: The Cruise ship "Diamond princess" arrived at the port of Yokohama on 3rd February 2020 and received world attention due to reported confirmed case in the ship. On 5th February, after a report of confirmed case, passengers were asked to stay in their rooms in the ship for quarantine and to avoid spread. At that time, there were 3711 individuals, which includes 1045 crew members. Although there was an initial delay in testing, Disaster infection Control Team (DICT) under the Japanese Society for Infection Prevention and Control started conducted test in the ship along with DMAT (Disaster Medical Assistance Team) [9]. DICT team comprised of approved infection control doctors, approved infection management nurses, as well as experts from university hospitals and other institutions. The crew members were provided with personal protective equipment (PPE) and instructed on appropriate IPC (Infection Prevention and Control) practices. The passengers were given thermometers and asked to record their body temperatures. Those passengers with lab-confirmed

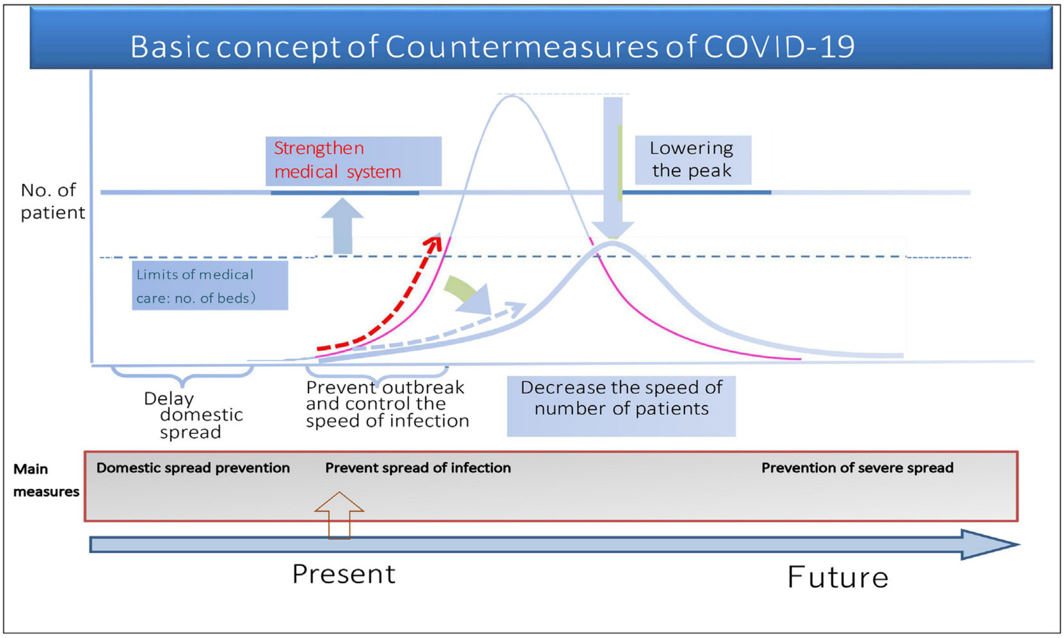

Fig. 4. Basic concept of countermeasures of COVID-19. (Translated and prepared by authors from original figure of MoHW [13]).

COVID-19 were disembarked and transferred to an isolation ward at healthcare facilities [10]. There was a zoning planned in the ship for the infected areas, as well as to store the infection prevention gears. With regards to the passengers, guidance was given through the in-cruise announcement repeatedly, and the video on the appropriate ways to remove masks and to sanitize fingers, created by the DICT, was delivered to the smart phones provided to each passenger for public awareness. As of 18th February, there have been 531 confirmed cases (14.3% of all individuals on board on 5 February), including 65 crew and 466 passengers. Based on the number of confirmed cases by onset date, there is clear evidence that substantial transmission of COVID-19 had been occurring prior to implementation of quarantine on the Diamond Princess on 5 February [10]. The disembarkation of all passenger was completed on 27th February.

Border control phase to Infection spread phase: Japan has been doing Border Control measures (*Mizugiwa Taisaku* in Japanese) to control the spread of infections in Japan. The measures in Diamond Princess is the reflection of that. Also, Japan had put specific measures to control inbound visitors from Hubei province and asking for filling up health forms, as well 14 days quarantine. However, from 15th of February, there have been reports of transmission cases for which routes could not be identified. In such situation, the focus shifted from Boarder control to infection spread control phase [11]. As of February 20, three deaths have been reported, and severe cases have started to be reported in the elderly and patients with underlying diseases. As per the experts, during the epidemic phase, the treatment of the serious patients was required. Border control measures continued with quarantine restrictions on travel of passengers from China and Korea on 5th of March, which gradually extended to other high-risk countries also. Once the disease started spreading, it was essential to identify the clusters from where it started spreading, which is stated below.

Cluster approach: The analysis by Tohoku University virology professor Hitoshi Oshitani, who is on a government panel of medical experts, comes as Japan ramps up contact tracing efforts with a focus on "active epidemiological investigation". On 25th February, MHLW prepared "Cluster Response Section," in accordance to the Basic Policies for Novel Coronavirus Disease Control. The cluster approach targeted to identify the cluster to spread the disease, and quickly take actions to stop the spread from the clusters. Japan has identified 15 coronavirus clusters nationwide in its first "cluster map", released on 16th March. Although the data changes over time, in the map, the biggest cluster, which accounts for more than 80 cases, involves four live music venues in Osaka. Another live house in Sapporo was also identified as a cluster [8]. Keeping in mind the increasing growth of affected patients, as well as identification of clusters, the Governor of Hokkaido had announced "a state of emergency" in Hokkaido on 28th of February and urged the residents to stay indoor over the weekend.

Temporary closure of schools across nation: Prime Minister Shinzo Abe had requested for the voluntary closure of school in the last week of February, and as a result, most of the schools across nations were closed from 3rd of March 2020. This apparently abrupt decision drew criticism from many schools, teachers and parents since it was announced with little preparation. However, this decision was on the crucial trigger to increase the urgency in people's understanding and actions. The only effective way at the moment to prevent the spread of this novel coronavirus is decrease personal contact among people and to increase personal hygiene, such as hand-washing [8].

Basic Policies for COVID-19: On 25 February, the Abe Administration adopted the "Basic Policies for Novel Coronavirus Disease Control" based on the advice that it received from the Expert Meeting. First, the new policies advised local medical institutions that it is better for people with lighter, cold-like symptoms to rely on bed rest at home, rather than seeking medical help from clinics or hospitals. The policy also recommends people at a higher risk of infection -including the elderly and patients with pre-existing conditions – to avoid hospital visits for such non-treatment purposes as completing prescription orders by letting them fill the forms over the telephone instead of in person. Second, the new policies allow general medical facilities in areas of a rapid

COVID-19 outbreak to accept patients suspected of infection. Before this, patients could only get tested at specialized clinics after making an appointment with consultation centers to prevent the transmission of the disease. Third, the policy asks those with any cold symptoms to take time off from work and avoid leaving their homes. Government officials urged companies to let employees work from home and commute at off-peak hours. The Japanese government also made an official request to local governments and businesses to cancel large-scale events.

Telework has been promoted very strongly with the private and public companies. However, in spite of several appeals, it was found that only 13% of are doing telework, while 38% who wish to do telework could not due to several issues, including technical problems [12]. The survey was conducted between 9 and 15 March with 21,000 company employees.

On 5 March 2020, Prime Minister Abe introduced a draft amendment to the "Special Measures Act to Counter New Types of Influenza of 2012". This would allow the Prime Minister to declare a "state of emergency" and mandate the prohibition of large-scale gatherings and the movement of people during a disease outbreak.

The basic countermeasures of COVID-19 is presented in the Fig. 4 (MoHW, [13]). There are three phases considered in this approach: 1) domestic spread prevention, 2) prevent spread of infection, and 3) Prevent severe spread. It seems that Japan is currently in the second phase, which aims at preventing spread of infection. The key target is to reduce the number of affected people by lowering the peak, and strengthening medical system. The crucial in this phase is to prevent the outbreak and control the speed of infection, so as to provide enough time to the medical facilities to get prepared. This can be done also with strengthening other countermeasures like border control, identifying key clusters, closing of school, promoting telework, and avoiding gathering of people in public places like abandoning key sports events, festivals (like cherry blossoms viewing) etc.

3.3. Republic of Korea (South Korea)

(1) The occurrence of first confirmed case and subsequent successful initial management: From the beginning of the COVID-19 situation, the Korean government, centered around the Korea Centers for Disease Control and Prevention (KCDC), has shared information with related organizations and established an effective response system.

When reports were received of pneumonic patients arising from an unknown origin in Wuhan, China, in December 2019, the KCDC strengthened the quarantine process for people entering Korea from the Wuhan region in cooperation with Chinese health authorities and the World Health Organization (WHO). After a 36-year-old woman of Chinese nationality was classified as suspected of hosting the novel disease and quarantined on January 8, 2020, the Korean government issued a Blue Alert Level (the lowest among the 4 alerts along the national crisis management system) and established a joint response system by sharing immigration information among the KCDC, the Ministry of Interior and Safety (MoIS), the Ministry of Justice (MoJ) and other related agencies.

On January 20, 2020, the KCDC confirmed the first imported case of COVID-19. The case was a 30-year-old Chinese woman living in Wuhan, China, and four days later confirmed the second imported case; a 55-year-old Korean male working in Wuhan. On the same day, the Korean government raised the alert level from Blue (Level 1) to Yellow (Level 2) and set up the Central Discharge Countermeasures Headquarters (CDCHQs) to initiate the 24-hour emergency response system [14]. In addition, the KCDC began to conduct a thorough survey of all visitors from the Wuhan region to prevent the influx of potentially infected people, and to strengthen the quarantine and public relations efforts to prevent the spread of COVID-19 during the lunar new year holiday season; a time when millions of people are on the move. Accordingly, President Moon emphasized that the government should mobilize all available resources to prevent the spread of COVID-19 and conduct a thorough investigation on all visitors from Wuhan, leading to a transparent disclosure of processes and results [15].

On January 30 and 31, 2020, the Ministry of Foreign Affairs, MoIS, and related ministries worked together to transport Koreans residing in Wuhan, China, back to Korea. MoIS formed a joint government support group to ensure the returnees were regularly monitored while adhering to a 14-day quarantine at the government facilities in Asan City and Jincheon City. Thanks to the government's transparent and proactive response, step-by-step strengthening of foreign entry procedures, and voluntary participation by citizens to self-quarantine and self-isolate, there were only 30 confirmed cases of COVID-19 by February 18. The situation seemed to gradually be turning to a stable phase.

(2) The rapid escalation of COVID-19 by members of the "Shincheonji Church of Jesus": As the number of confirmed cases surged due to the unexpected "Shincheonji" emergency, the Korean government raised the alert level to Red (Level 4) and put all available resources to tackle the crisis along with designating special management regions against infectious diseases.

On February 19, the KCDC identified the 31st confirmed case who was a 61-year-old Korean female, a member of Shincheonji. Just after that the number of confirmed cases spiked and most of them came from the Shincheonji Cluster. The COVID-19 situation in Korea took on a completely new aspect of the noble crisis situation. Consequently, the Daegu City government acquired a list of the 9336 Shincheonji members from the headquarters of the Shincheonji and cross referenced the list with the KCDC, then asked all members to be tested for symptoms and to self-isolate. The Korean government subsequently scaled up the alert level to Red (Level 4) and took extreme proactive actions in order to avoid a nation-wide transmission. As a follow up activity, Central Disaster and Safety Countermeasures Headquarters (CDSCHQs), headed by the Prime Minister, were installed [16]. The HQs focused on isolating and treating potential cases in the specially managed regions of Daegu City and Cheongdo-gun in Gyeongbuk province, and in other regions conducted epidemiological investigation and environmental disinfection to prevent a sporadic community epidemic as well as to identify Shincheonji-related cases.

(3) Protecting Daegu and Gyeongbuk and stopping a national spread: The government's transparent and democratic response, the voluntary participation of citizens, and the efforts of hidden heroes prevented the spread of Covid-19 nationwide.

On February 26, the total number of confirmed patients was 1261, and the rapid increase raised the sense of a crisis across the country. Among them, the confirmed cases in Daegu and Gyeongbuk were 75% of the cases with 945 confirmed patients. Instead of blockading the Daegu and Gyeongbuk regions, the Korean government conducted a thorough survey of the members of the Shincheonji Cluster, who triggered the community spread in Daegu and Gyeongbuk; feasibly across the country, and conducted around 10,000 diagnostic tests per day to quickly identify confirmed cases.

At the same time, measures were implemented to secure the necessary beds for the cases with the highest severity, and to solve the shortage of medical staff. In cases where life was threatened, patients were hospitalized and placed in negative pressure rooms or moved to infectious disease designated hospitals. Non-threatening cases were provided with medical support at a designated 'Life treatment Center' within each region. Moreover, Doctors and nurses from other regions voluntarily and swiftly ran to Daegu and Gyeongbuk to relieve the shortage of medical personnel. The Korean government also expedited the hiring of 724 public health doctors earlier than originally planned and deployed them to each region. On March 4, the KCDC developed and implemented standard operating guidelines for drive-through testing centers as an effective and rapid diagnostic test processing destination versus hospitals; multitudes quickly opened soon after. Additionally, 254 hospitals were designated as 'for public use;' a hospital the public could visit without fear of infection.

The Korean government continued its vocal call and support for citizenry participation in personal hygiene practices and social distancing. The MoIS, by this time, had developed and released a safety protection application for self-isolated people to self-diagnosis their health status, to be informed of self-isolation life rules, and to automatically send alerts to a dedicated official when the person leaves the self-isolation site without approval. Also by this time, as sales and usage of face masks spiked, temporary mask shortages began to be felt by everyone. To mitigate potential problems, the Ministry of Food and Drug Safety (MFDG) implemented a five-day rationing system for selling and purchasing facemasks.

On March 13, the government prepared guidelines for stronger preventative measures towards the usage of public spaces, call centers, and facilities that could accommodate many people. Religious groups cooperated with the government measures and calls by holding weekly worships online and postponing or canceling large-scale religious events.

With the government's proactive actions and citizens' participation, the number of confirmed cases decreased to 75 on March 15 and gradually began to show a stabilizing trend.

(4) Preventing overseas re-inflow and strengthening physical distancing: The Korean government applied special entry procedures to block the influx of COVID-19 from foreign countries, and shifted physical distancing policy from a voluntary participation to a strong administrative recommendation.

With the declaration of the Corona Pandemic by the WHO and the rapid expansion in the number of confirmed cases in Europe and the United States, concerns about a re-influx of COVID-19 hosts from overseas to Korea began to increase.

On March 15, the Korean government expanded the scrutiny of special entry procedures to those entering from five European countries: France, Germany, Spain, the UK and the Netherlands; on March 19, travelers from all countries received special scrutiny. In addition, the government strengthened countermeasures to block the re-introduction of foreign risk factors into Korea; including a 14-day self-isolation for all travelers from Europe and a special travel advisory for Koreans, urging the cancellation or the postponing of all overseas trips until mid-April at the very earliest. Moreover, the Korean government started to support the return of Korean citizens residing abroad; starting with those in Iran. Upon arriving at Incheon Airport, returnees were tested, and if found to be negative of the virus, they agreed to self-quarantine at home. If found to be positive, returnees were taken directly to a hospital for treatment.

The two policies of postponing the start of schools' spring semesters and forcing social distancing had been stronger measures that the Korean government took to tackle the COVID-19 spread. It was on March 18 that the special decision was taken to delay the start of the spring semester for daycare centers, kindergartens, elementary schools, junior high schools, high schools, and special schools nationwide by April 6. On March 21 and 22, the government strongly recommended to facilities with a high risk of collective contagion, such as religious facilities, indoor sports facilities, and entertainment venues, to close their doors to the public for two weeks, and asked all citizens to refrain from gathering at multi-use facilities and indoor sport arenas, or doing outdoor activities collectively for the same period.

4. Commonalities and key lessons

4.1. Governance

Different countries have different styles of governance. This section summarizes some of the key lessons on governance at different level.

4.1.1. National government's decision

Strong government control: China showed a very strong government control from the third week of January when the COVID-19 case was officially confirmed. Apart from the lockdown in Wuhan, Hubei province, and gradually to all over the country, there was strict measures not to promote fake news and panic from the initial stage. Supreme court advisory was issued on the fake news at an early stage. Also, different provincial governments helped the most affected province and city (Hubei and Wuhan) with different types of supplies and resources.

Transparency and democracy: South Korea proved to be successful in responding to COVID-19 through disclosing accurate information transparently and holding to the democracy of the whole society [17]. Since January 20, 2020, when the first COVID-19 case was confirmed, the Korean government, centered around the KCDC, shared relevant information among the WHO, Chinese authorities and other related agencies, and transparently disclosed the government's responses; leading to voluntary participation of citizens without protest.

The national and local governments of Korea quickly identified the movement path of the confirmed cases through big data analysis; data obtained through credit card usage history, CCTV analysis, etc., and disclosed them transparently through the Cell Broadcasting System's (CBS) mobile service and government's website [18]. The citizens who received the information were able to determine whether or not they had contact with the confirmed case. If so, most citizens voluntarily reported to a public health center. If they showed any signs of having the virus, a diagnostic test was requested. Due to the fact that the Korean government is well prepared for testing and conducting diagnostic analyses, all potentially infected citizens were able to be promptly analyzed, resulting in preventing the spread of infectious diseases.

Clear roles & responsibilities and Unified efforts: An effective response against a novel infectious disease like COVID-19 requires a very specialized knowledge and expertise, thus it is essential to develop and implement a holistic response plan by an expert group. From the beginning of the COVID-19 response, the Korean government set up a decision-making process centered around the quarantine countermeasure headquarters operated by the KCDC. On top of that, as the government-wide response became more vital due to the rapid increase in the number of confirmed cases, MoIS took charge of the monitoring and management of people self-isolating, finding and surveying those who had visited the Wuhan region and may be contagious, locating and securing temporary living facilities and lifetime treatment centers through Countermeasures Support Headquarters (CSHQs). This delineation of roles and responsibilities between the responsible agency (KCDC) and the coordination agency (MoIS) made it possible for the KCDC and the Ministry of Health and Welfare (MoHW) to focus on epidemiological investigations and responses to the infectious disease.

This effective response system was developed based on the double-loop learning process during the MERS experience in 2015, the novel swine-origin influenza A(H1N1) in 2009, and severe acute respiratory syndrome (SARS) in 2003. Consequently, the successful COVID-19 response can be directly attributed to the leadership of the President to accurately understand the fluctuating situation and emerging risk factors, and make accurate decisions based on the advice of expert groups, and the dedication of the Prime Minister who stayed in the Daegu and Gyeongbuk regions for three weeks to concentrate the capabilities of all ministries to cope with the crisis situation.

Expert based advices: Japan took a different cautious approach not to call for a national emergency and lockdown. The legislation in Japan does not permit a forced lockdown, but a request/advisory for the lockdown. Japan's decision was based on close interaction with the expert group, which comprised of a diverse experts from the medical side, as well as economic, political and social side. Based on the expert advices, regular government briefings and press meet by the Prime Minister,

minister or senior officials were arranged. Japan's governance approach was to flatten the growth curve, so that the health response mechanism has enough time and resources to respond to the situation, and that would possibly provide enough time to develop the vaccine and preventive measures.

4.1.2. Provincial/local government's decision

Proactive prevention activities: The Seoul and Gyeonggi-do governments; with the highest populations in Korea, took proactive measures from the initial outbreak. The Seoul City government promptly produced and distributed guidelines on special entry procedures detailing the diagnosis and preventive tips for a corona virus, and temporarily restricted the use of large public squares. In addition, after a mass infection occurred at the Guro Call Center, the Seoul city government urgently conducted a survey of 417 private call centers and feasibly prevented a spread of COVID-19 by improving the environment for telecommuters [19]. The government of Gyeonggi-do, where the headquarters of the Sincheonji Church of Jesus is located, conducted a thorough investigation of all Sincheonji churches in the region and ordered the temporary closure. Also, it ordered the members of the Shincheonji to report to local public health centers and to self-isolate.

In Daegu City and Gyeongbuk Province, where the largest number of confirmed cases were identified, the governments established a system for investigating all members of the Shincheonji and monitoring them exclusively by public officials. In addition, when hospital capacities became overwhelmed by the influx of patients, the government ordered the use of negative-pressure beds for the treatment of cases of highest severity only, and moved the cases with less severity out of the hospitals and into life treatment centers equipped with makeshift facilities where people could recover. Business sectors, religious group and other regional governments assisted Daegu and Gyeongbuk during the crisis. For example, companies such as Samsung and LG, and the religious community provided their training centers and facilities as life treatment centers. Other local authorities including Gwangju Metropolitan City persuaded its citizens to open its hospitals and facilities for patients from Daegu and Gyeongbuk so that the regions could recover more rapidly.

In case of China, Hubei province showed a strong leadership in implementing stricter measures within the province. In Japan, Hokkaido announced an emergency in early March, and restricted gathering in public spaces. Also, several other prefectures in Japan (like Osaka, Hyogo) advised not to travel between the prefectures. Tokyo Metropolitan Government also communicated with neighboring prefectures to advise travel limitations.

Prompt dissemination of the movement path of the confirmed cases: Local governments, in cooperation with the KCDC, quickly identified the movement path of the confirmed cases and informed the residents of the areas in real-time via mobile text message using the CBS. In addition, they promoted safety rules through 24-h broadcasts, and posted on the governmental homepages COVID-19 prevention tips and the movements of confirmed cases so that any citizen could find the information at any time.

4.1.3. Community governance

Community-based activism, such as aggressively finding suspected cases and supporting vulnerable groups, was another advantage of Korea to overcome the crisis. For example, in Chungcheongbuk-do, a safety group organized from community units; such as a grassroots women's group and safety guards, actively participated in finding the people suspected of carrying the virus, and in sympathetically and humanly reported them to the Community Service Center. In Chungju city and Boryeong city, local autonomous disaster prevention groups and women's associations voluntarily disinfected multi-use facilities and vulnerable facilities. Furthermore, as the phenomenon of mask shortages across the country became serious, members of non-profit organizations such as the Jeju Women's Association of Seogwipo city and the Cheonan city Happiness Support Group started to produce face masks for those incapable of easily securing supplies far from home such as the elderly and the disabled.

China also showed strong community governance with people making their community watch to strictly maintain the entry or exit from the community. This was not only implemented in the urban areas but also in the rural areas.

4.2. Innovative technologies

Several innovative technologies were used in different countries to identify affected people, to check their mobility, to reduce the risk of contamination, as well as to develop proactive recovery strategies and actions. Artificial Intelligence (AI), Big data, 5G technologies were used in combination with other emerging technologies like drones, automated vehicles, robotics etc.

In case of China, on 14th of February, the Ministry of Transport of People's Republic of China [20] issued a circular to use new technologies for addressing COVID-19 risk as well as to develop recovery strategy. Highlights of China's use of technologies are described as follow:

AI: Fudan University and Shanghai city government, along with the CDC (Center for Disease Control) develop a unique AI based medical screening and check-up for respiratory blockage, which enhanced the speed of decision making of the scan system. The system was used with more than 93% of Shanghai residents to make quick scan of the respiratory system [21].

Big data: Baidu big data was used to identify clusters of infected people. People's mobility data was used to identify movement of people from one place to another during an early stage of spread of the disease, which helped to take critical decisions on lockdown certain high-risk areas. This was also used in the recovery process, when the shops or factories are reopened to identify potential future risk areas as well [22,23].

5G: 5G data was used extensively in combination with different other technologies. Primarily, it was used in transport system to identify the mobility of vehicles and related information (like number plates, driver etc.). Combination of drones and 5G was used in the transport system to identify violation of laws in the emergency time. Thermal camera was used with helmet of police and other public officials for quick thermal screening of people in Guangdong, and the date was sent using 5G. Combination of robotics and 5G was used for city sanitization in the peak period in Wuhan when public services were also at risk. Similarly, combination of automated vehicle and 5G was used for goods delivery in certain highly contaminated areas. 5G was also used for tele-medical care and advices in the newly built hospital in Wuhan. [21,24].

Health barcode: A unique health barcode system was developed to identify the affected people, as described in Hua and Shaw [7]. Hangzhou city was first to use this system on 11th of February 2020, which gradually used in 200 other cities in China [25] For developing the health barcode, user sign up for the “close contact detector” app by registering their phone number, name and ID, and then scanning a QR code on their smartphones [26]. The app will tell them whether they have been in proximity to someone who has been infected. The barcode system has three color coding: green (good health), yellow (caution required), and red (infected people), which enable or disable them to entering from different public buildings as well as public transport. With the health barcode, online mapping of affected people could be done, and people could avoid the clusters where affected people are concentrated. If a user is found to have in close contact with the affected person, the app recommends self-quarantine and also send an alert to health officials. Career's big data was used in combination with Baidu's location (GPS) data to develop the health barcode. This was also used in Wuhan on 18th February onward, and eventually to all Hubei province from 10th March onward. On 21st March, the government announced to develop health information platform for the whole country using the same system. Chen [26] argued positive and negative consequence of the system on the ground that tools like surveillance and epidemic maps need to be combined with a view of how people react under pressure.

Rapid diagnostic test kit and an innovative test method: In Korea, the development of a kit for rapidly diagnosing the potentially infected and innovative test methods such as drive-through screening centers, enabled thousands of people to be tested every day. This large-scale diagnosis for COVID-19 was able to detect and confirm cases in their early stages, thus lowering the fatality rate and preventing the wide spread of the infectious disease. The new diagnostic kit using Real-time reverse Transcription Polymerase Chain Reaction (RT-PCR) reduced test time from 24 h to 6 h. This kit was able to be used thanks to the efforts of a small business company that has been working on development irrespective of deficits and the rapid approval by the KCDC and MFDG. The KCDC and the MFDG reduced the administrative process, which normally takes one year from development to approval, to one month, so that it could be applied quickly in the field [27].

In addition, the drive-through screening method made it possible for suspected cases to receive the result of the COVID-19 diagnostic test from their vehicle within 10 min, reducing the risk of cross-infection. While the general screening center took 2 samples per hour or 20 possible cases per day, the drive-through method was able survey 6 people per hour and 60 possible cases per day [28]. The United States and Germany already adopted this driving-thru method as a way to reduce the possibility of cross-infection and increase the efficiency. In Korea, the 'Walk-Thru Test Booth' and 'Open Walk-Thru Booth' evolved from the drive-through screening method. For this method, a potential patient enters a booth, and then a medical staff securely outside the booth checks their condition verbally via an intercom and take on-the-spot samples from patients outside the booth by using a stethoscope. This method takes only 6–7 min per person and results in a much smaller chance of contagion thanks to a complete separation between patient and doctor. On March 16, the Yangji Hospital, located in Seoul, started to implement this method for the first time; on March 25 the Korean government installed the Open Walk-through Booth at Incheon Airport in order to deal with the thousands of travelers from overseas countries.

Enhancing self-responsibility and improving administrative efficiency using ICT: The KCDC developed a self-diagnosis mobile application to strengthen monitoring by allowing domestic and foreign travelers entering Korea to self-diagnose fever and health conditions related to COVID-19, and report it to their local health center or the KCDC. As users typed quarantine-related information such as passport information, nationality, and names in the app, the KCDC was able to monitor their status during their stay in Korea [13,29].

In addition, the MoIS developed a self-quarantine safety protection mobile application to reduce the enormous administrative costs used to monitor self-isolators by public officials for local governments. In general, public officials check the status of self-isolators by daily phone or irregular visit, but they cannot prevent people from leaving home without approval. This app helped to overcome previous shortcomings by including a GPS function, so if a self-isolating person left their home without approval, a warning message is automatically sent and a dedicated official is notified and sent to the scene to prevent the patient from violating the self-isolation if necessary. This app allows self-isolating people to complete self-isolation under their own responsibility, and frees-up vital officials by allowing many administrative personnel not to have to visit the self-isolators' home or check their status by phone regularly [30].

4.3. Citizen behavior

Compliance with citizens' voluntary codes of conduct and refrain from large-scale gatherings of religious groups: A group outbreak occurred in Daegu and Gyeongbuk after the 31st confirmed case was announced; a Shincheonji believer in Daegu, but the national government did not take any mandatory blockade measures in this regions, instead provided all financial and administrative support so that Daegu and Gyeongbuk could overcome difficulties. The citizens in Daegu and Gyeongbuk also voluntarily participated in refraining from leaving their homes, self-reported 1339 cases of suspicion, and complied with stricter hygiene rules. The phenomenon of stockpiling daily necessities did not appear. Citizens from other regions faithfully fulfilled the government's request to refrain from visiting Daegu and Gyeongbuk.

All over the country, citizens made washing their hands a daily life habit. In business offices, public facilities, and facilities where large numbers of people come and go, hand sanitizers had been prepared so that people could use them freely and frequently. Citizens wore face masks when going out in order to prevent the spread of the infection. For example, the third confirmed person in Incheon on February 25, 2020, voluntarily stopped working and began self-isolating at home as soon as a suspected symptom occurred. He even wore a face mask inside the house and refrained from going out. Thanks to his efforts, all the 23 people who were in contact with him; including his mother whom he lived together with, proved to be negative.

Most religious groups also refrained from large-scale gatherings by conducting online worship services and delaying Buddha's Day celebrations, and actively participated in the "Social Distancing" campaign.

Nation-wide volunteer and donation: By the end of February 2020, the number of confirmed patients had rapidly increased in Daegu and Gyeongbuk, making medical examination and treatment of all confirmed and suspected cases in the regions impossible. Upon hearing their desperate circumstances, medical doctors, nurses, and clinical pathologists from all over the country moved in to provide medical treatment, assistances, and relief. According to the CDSCHQs, from February 24 to February 27, a total of 853 people (58 doctors, 257 nurses, 201 nursing assistants, and 110 clinical clinicians) participated in volunteer services [13]. In particular, more than 3000 people applied to volunteer as a nurse, and Korea was able to find hidden heroes such as nurse Kim who gave up her immigration to the United States in the process of applying for this volunteer service, or nurse Oh who sent a sincere letter saying, "If I am not selected as a volunteer, I would suffer the fact that I can't help others in trouble. [31]". They stayed in Daegu and Gyeongbuk for more than a month, devoting themselves to the treatment and prevention of the infection. Additionally, the president of a hotel in Changwon City provided hotel rooms free-of-charge for the volunteering medical doctors and nurses who had a hard time finding adequate accommodations. Efforts were also made to overcome COVID-19 on the basis of community consciousness, such as donations from all around the country.

Good landlord movement: With the prolongation of COVID-19, consumption contracted significantly and the domestic economy was starting to stagnate. As the economic crisis for small business owners or self-employed people with a large rent burden increased, the "good landlord movement" that temporarily lowers rent spreads across the country. For example, more than 5000 stores in Dongdaemun Market, Gwangjang Market, and Tongin Market in Seoul City participated in the ‘good landlord’ campaign and cut the rent by 20–30%. In addition, a variety of “Good Landlord Movements”, such as the exemption of franchise commissions from the food brand Chaeseondang, and a subsidy of 1 million Korean won for affiliates of mega coffees, gave hope to the small-business owners facing difficulties.

Community support and solidarity: Chinese people showed a strong level of community solidarity for the affected people in Wuhan. Not only they provided resources, including financial, human resources, they also helped in boosting morals of the frontline health workers, and shared different positive stories and experiences through the social media.

5. Way forward

While the world is still struggling with the pandemic, the number of confirmed cases and casualty is growing higher, the East Asian examples and analysis draw a few important lessons as follow:

Pandemic is global, **but its response is local**: In the growing interconnected world, our movement is quite high and fast, and that possibly enhanced the spread of the virus globally very quickly, making it a global pandemic. However, different country showed differences in approaches in responses. Thus, although the medical treatment is universal, we need to keep in mind that the healthy emergency response measures are not universal. It is a combination of country's regulation, governance mechanism, link to science-based decision making, local governance as well as community behavior. Thus, learning from each other's experience is very important.

Use of technology: In the advanced stage of technological intervention, a pandemic response is not just a medical response anymore. It needs to link different types of technologies in an appropriate way. COVID-19 response in East Asia showed extensive use of emerging technologies (like big data, AI, drone, 5G, robotics, automated vehicle, block chain etc.) linked to medical technologies.

Risk assessment: Djlante et al. [32] in a quick analysis has pointed out the need of converging the health response, emergency response and disaster risk reduction in the viewpoint of the Sendai Framework. They analyzed and concluded that current mechanisms and strategies for disaster resilience, as outlined in the SFDRR, can enhance responses to epidemics or global pandemics such as COVID-19. Some of the recommendations are as follow: recommendations concern knowledge and science provision in understanding disaster and health-related emergency risks, the extension of disaster risk governance to manage both disaster risks and potential health-emergencies, particularly for humanitarian coordination aspects; and the strengthening of community-level preparedness and response. A proper risk assessment is required taking into consideration of health risk, exposures, behaviors and policy framework.

Use of social media and sensitization on fake news: In different countries, with different level of social media penetration, the importance of distinction of proper news and fake news becomes more relevant. Importance of negative consequences of fake news is well understood in longer run, not only to fight this pandemic, but also for the longer-term recovery process.

Economic implications: The global economic impacts of the pandemic are yet to be understood, but there is a unanimous agreement of a global recession due to the pandemic. However, in different countries, sectorial impacts are already prominent, especially in tourism and hospitality sectors. MSMEs (Micro, small and medium enterprises) are possibly the hardest hit in all the countries need special economic revitalization package.

Socio-psychological impacts and lifestyle changes: Country wide or partial local down in cities have initiated a different work culture in East Asian countries, as well as in most of the other countries. Tele-work is becoming popular, online meetings, online classes in the universities are getting common, online education for school children becoming obvious. Thus, there has been a life-style change in many countries and communities, which may have relatively longer socio-psychological and behavioral implications.

CRediT authorship contribution statement

Rajib Shaw: Conceptualization, Methodology, Formal analysis, Writing - original draft.**Yong-kyun Kim:**Formal analysis, Writing - original draft. **Jinling Hua:**Formal analysis.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

References

[1] Zaroncostas J (2020): How to Fight an Infodemic in www.thelancet.com, Vol 395, Accessed on: 29th February, 2020

[2] Wu Z. and McGoogan J. M. (2020): Characteristics of and important lessons from the coronavirus disease 2019 (COVID-19) outbreak in China in JAMA: JAMA. Published online 24th February 2020. doi:https://doi.org/10.1001/jama.2020.2648, Accessed on 21st March 2020

[3] Roy M Anderson, Hans Heesterbeek, Don Klinkenberg, T Déirdre Hollingsworth (2020): How will country-based mitigation measures influence the course of the COVID-19 epidemic? In Lancet: doi:https://doi.org/10.1016/S0140-6736(20)30567-5, Accessed on 23rd March 2020

[4] John Hopkins (2020): Corona virus resource center, available at: https://coronavirus.jhu.edu Accessed on 23rd March 2020

[5] WHO. Rolling updates on coronavirus disease (COVID-19). available at: https://www.who.int/emergencies/diseases/novel-coronavirus-2019/events-as-they-happen; 2020, Accessed date: 23 March 2020.

[6] Mckinsey. Coronavirus COVID-19: Facts and Insights, USA; 2020 (16 pages).

[7] Hua J, Shaw R. Corona virus (COVID-19) infodemic and emerging issues through a data lese: the case of China. Int J Environ Res Public Health 2020;17 (DOI:).

[8] Wiki. 2020 Coronavirus pandemic in Japan. available at: https://en.wikipedia.org/wiki/2020_coronavirus_pandemic_in_Japan; 2020, Accessed date: 26 March 2020.

[9] MHLW. The infection control measures taken at the Cruise ship “Diamond Princess”. available at: https://www.mhlw.go.jp/stf/seisakunitsuite/newpage_00001.html; 2020, Accessed date: 26 March 2020.

[10] NIID. Field briefing: diamond princess COVID 19 cases. available from: https://www.niid.go.jp/niid/en/2019-ncov-e/9407-covid-dp-fe-01.html; 2020, Accessed date: 26 March 2020.

[11] Kankyokansen. New coronavirus infection (COVID-19)-from border control to the stage of transmission (in Japanese). available from: http://www.kankyokansen.org/uploads/uploads/files/jsipc/covid19_mizugiwa_200221.pdf; 2020, Accessed date: 26 March 2020.

[12] PRC (2020): Persol Research and Consulting Company Survey of Telework in Japan for COVID-19

[13] MoHW. COVID-19 CDSCHQs press release. available from https://www.mohw.go.kr; 2020, Accessed date: 28 February 2020.

[14] KCDC. The first imported case of the novel coronavirus (2019-nCoV) in Korea. avaiable from https://www.cdc.go.kr/board/board.es?mid=a30402000000&bid=0030; 2020, Accessed date: 28 March 2020.

[15] Cheongwadae. Opening remarks by President Moon Jae-in at 7th cabinet meeting. available from http://english1.president.go.kr/BriefingSpeeches/Speeches/759; 2020, Accessed date: 28 March 2020.

[16] Cheongwadae. Opening remarks by President Moon Jae-in at meeting for pan-government COVID-19 countermeasures. available from http://english1.president.go.kr/BriefingSpeeches/Speeches/764; 2020, Accessed date: 28 March 2020.

[17] Normile D. Coronavirus cases have dropped sharply in South Korea. What's the secret to its success? Science 2020 available from www.sciencemag.org/news/2020/03/coronavirus-cases-have-dropped-sharply-south-korea-whats-secret-its-success, Accessed date: 21 March 2020.

[18] KCDC. Contact transmission of COVID-19 in South Korea: novel investigation techniques for tracing contacts. Osong Public Health Res Perspect 2020;11(1):60–3. https://doi.org/10.24171/j.phrp.2020.11.1.09.

[19] Seoul Metropolitan Government (SMG). Seoul enforces concentrated disinfection due to mass COVID-19 outbreak. available from http://english.seoul.go.kr/seoul-enforces-concentrated-disinfection-due-to-mass-covid-19-outbreak/?cat=29; 2020, Accessed date: 21 March 2020.
[20] MOT. Ministry of transport of the People's Republic of China. http://www.mot.gov.cn; 2020, Accessed date: 29 March 2020.
[21] JingjiCCTV. http://jingji.cctv.com/; 2020, Accessed date: 29 March 2020.
[22] BBD. Baidu big data. available from https://voice.baidu.com/act/newpneumonia/newpneumonia/; 2020, Accessed date: 29 March 2020.
[23] CAC. Cyberspace Administration of China. http://www.cac.gov.cn/; 2020, Accessed date: 29 March 2020.
[24] MIIT. Ministry of industry and information technology of the people's Republic of China. http://www.miit.gov.cn; 2020, Accessed date: 29 March 2020.
[25] XINHUANet. http://www.xinhuanet.com/politics/; 2020, Accessed date: 29 March 2020.
[26] Chen A. China's coronavirus app could have unintended consequences. MIT Technology Review; 2020 Accessed from https://www.technologyreview.com/s/615199/coronavirus-china-app-close-contact-surveillance-covid-19-technology/, Accessed date: 25 March 2020.
[27] MFDG. D.U.A process for COVID-19 in Korea. available from http://blog.naver.com/kfdazzang/221874407188; 2020, Accessed date: 28 March 2020.
[28] Mi Lee Kyoung, Jihae Lee. Drive-through trend sweeps across multiple sectors, Korea.net. available from http://www.korea.net/Government/Current-Affairs/National-Affairs/view?affairId=2034&subId=5&articleId=183720&viewId=53510; 2020, Accessed date: 25 March 2020.
[29] MoHW. Self diagnosis mobile app instructions. available from http://ncov.mohw.go.kr/selfcheck; 2020, Accessed date: 25 March 2020.
[30] MoIS. Self-quarantine safety protection app. available from https://www.mois.go.kr; 2020, Accessed date: 28 March 2020.
[31] Chosunbiz. “Application Letter” from Nurses dispateched to Daegu and Gyeongbuk. available from https://biz.chosun.com/site/data/html_dir/2020/03/23/2020032303256.html; 2020, Accessed date: 28 March 2020.
[32] Djlante R, Shaw R, DeWit A. Building resilience against biological hazards and pandemics: COVID-19 and its implications for Sendai Framework. Progress in Disaster Science; 2020. https://doi.org/10.1016/j.pdisas.2020.100080 April 2020.

Other websites consulted

[Baidu, n.d] Baidu. Available online https://voice.baidu.com/act/newpneumonia/newpneumonia, Accessed date: 27 March 2020.
[Caixin, 2020] Caixin 2020. Available online: https://www.caixin.com (accessed on 27 March 2020).
[CCTV News, 2020] CCTV News. Available online http://news.cctv.com; 2020, Accessed date: 11 March 2020.
[Chinese CDC, 2020] Chinese CDC. Available online http://www.chinacdc.cn; 2020, Accessed date: 27 March 2020.
[China Health Commission, 2020] China Health Commission 2020. Available online: http://www.nhc.gov.cn (accessed on 27 March 2020).
[Hubei Province Health Commission, 2020] Hubei Province Health Commission. Available online http://wjw.hubei.gov.cn; 2020, Accessed date: 27 March 2020.
[Sina News, n.d] Sina News. Available online https://news.sina.cn/zt_d/yiqing0121?wm=6122_1221, Accessed date: 26 March 2020.
[Sina Weibo, n.d] Sina Weibo. Available online https://www.weibo.com/, Accessed date: 27 March 2020.
[South China Morning Post, n.d] South China Morning Post. https://www.scmp.com, Accessed date: 27 March 2020.
[Tencent News, n.d] Tencent News. Available online https://news.qq.com, Accessed date: 27 March 2020.
[Wuhan Municipal Health Commission, n.d] Wuhan Municipal Health Commission. Available online http://wjw.wuhan.gov.cn, Accessed date: 27 March 2020.
[Wechat Public Platform, n.d] Wechat Public Platform. Available online https://mp.weixin.qq.com/, Accessed date: 27 March 2020.

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Corona Virus (COVID-19) "Infodemic" and Emerging Issues through a Data Lens: The Case of China

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Abstract: Coronavirus (COVID-19) is a humanitarian emergency, which started in Wuhan in China in early December 2019, brought into the notice of the authorities in late December, early January 2020, and, after investigation, was declared as an emergency in the third week of January 2020. The WHO declared this as Public Health Emergency of International Concern (PHEIC) on 31th of January 2020, and finally a pandemic on 11th March 2020. As of March 24th, 2020, the virus has caused a casualty of over 16,600 people worldwide with more than 380,000 people confirmed as infected by it, of which more than 10,000 cases are serious. Mainly based on Chinese newspapers, social media and other digital platform data, this paper analyzes the timeline of the key actions taken by the government and people over three months in five different phases. It found that although there was an initial delay in responding, a unique combination of strong governance, strict regulation, strong community vigilance and citizen participation, and wise use of big data and digital technologies, were some of the key factors in China's efforts to combat this virus. Being inviable and non-measurable (unlike radioactive exposure), appropriate and timely information is very important to form the basic foundation of mitigation and curative measures. Infodemic, as it is termed by WHO, is a key word, where different stakeholder's participation, along with stricter regulation, is required to reduce the impact of fake news in this information age and social media. Although different countries will need different approaches, focusing on its humanitarian nature and addressing infodemic issues are the two critical factors for future global mitigation efforts.

Keywords: COVID-19; Coronavirus; infodemic; humanitarian emergency; data science; good governance; citizen participation

1. Introduction

Coronavirus (COVID-19) started spreading in December 2019 and was noticed in early January 2020. It started spreading in China in mid- to late-January. Among the different types of confusion and information challenges, we need to recognize that COVID-19 is first and foremost a humanitarian challenge [1]. As of 24 March, 2020, the virus has caused the death of over 16,600 people worldwide with more than 380,000 people are confirmed as infected by it, of which more than 10,000 are serious. As many as 184 out of 195 countries are affected. Solving the humanitarian challenge is the key priority through proper preventive measures to stop its spread, as well as curative measure to develop a vaccine. The impact of this public health emergency has affected countries and communities in terms of economic, socio-psychological issues, as well as international relations.

"We're not just fighting an epidemic; we're fighting an infodemic", said WHO Director–General Tedros Adhanom Ghebreyesus at the Munich Security Conference on 15 February 2020. WHO Information Network for Epidemics (EPI-WIN) was launched as a new information platform after WHO declared COVID-19 as a Public Health Emergency of International Concern (PHEIC). The goal was to share customized information with specific target groups [2]. Finally, on 11th March, WHO declared it this as a pandemic.

"We know that every outbreak will be accompanied by a kind of tsunami of information, but also within this information you always have misinformation, rumors, etc. We know that even in the Middle Ages there was this phenomenon. "But the difference now with social media is that this phenomenon is amplified, it goes faster and further, like the viruses that travel with people and go faster and further. So it is a new challenge, and the challenge is the [timing] because you need to be faster if you want to fill the void...What is at stake during an outbreak is making sure people will do the right thing to control the disease or to mitigate its impact. So it is not only information to make sure people are informed; it is also making sure people are informed to act appropriately." Said Sylvie Briand, Director of Infectious Hazards Management at WHO's Health Emergencies Program and architect of WHO's strategy to counter the infodemic risk. This poses the real challenge of mitigating the risk occurring from Coronavirus.

One of the key issues of the "invisible disaster" is obtaining correct information. In 2011, Japan had a triple disaster, caused by an earthquake-induced tsunami, which caused a nuclear meltdown. A that time, there was a severe panic in and around Japan about the level of radiation, which was also an invisible disaster. However, radiation could be measured, whereas the level of penetration of the virus is not measurable. Therefore, providing the right information from a reliable source is the key issue in this type of pandemic.

Keeping this infodemic challenge in mind, this paper tries to analyze three months of happenings in China from December 2019 to February 2020, drawing and analyzing data from different Chinese websites, social media and research institutes. The value addition of this paper lies in the fact that original data were collected and analyzed in Chinese, and from Chinese social media. Although a characteristic information censorship exists in China, there were several positive and negative things that happened in the last three months. This paper is a narrative of those events and provides an original analysis.

There are three characteristics/impacts of the paper: (1) this is possibly the first analytical paper which uses firsthand social media and internet data and information from China to describe the time-series narrative in Wuhan and China with a focus on key policy decision, (2) it also uses original survey raw data to understand the types of media people used to get information, and (3) the reliance of different types of online services at different phases of the lockdown.

Of course, the paper has its own limitation, since, due to the evolving nature of the pandemic, the paper analyzes the spread in the original hotspot (although, as of late March 2020, the hotspot has shifted to Europe), which was Wuhan and the Hubei province of China. However, the key findings, which are described in Section 5, are useful to other parts of the world, which is currently suffering the impacts of COVID-19, as well as in future pandemic responses.

2. Characteristic of COVID-19

The data on Coronavirus are changing on daily basis, and it is difficult to provide current statistics for the affected, recovered and casualties. However, based on some initial studies, a few characteristics are emerging for this virus. It is reported that the case-fatality-rate (CFR) for Coronavirus was 2.3%, initially; however, the age group of 70 to 79 has an 8% CFR, and CFR is 14.6% for those more than 80 years old [3]. This means that the virus has a stronger impact on the aged population.

The other characteristic of the virus is its speed in spreading. When Dr. Zhong Nan Shan made a public announcement of this virus in CCTV on the 20th of January, the virus had already spread in different provinces in China, as well as outside China. Every day, some new countries are added to the list, which has already reached more than 100 countries and regions. It took only 30 days to spread from one city to the entire country of China. The early cases may have been spread from the Wuhan seafood market, while later cases were spread from person to person, the speed of which surprised the health workers in Wuhan city and Hubei province. The epidemic curve shown in [4] as well as presented later in this paper, shows that the second to the third week of January was the most crucial time, when the spread was very high.

There are some similarities and differences among COVID-19, Severe Acute Respiratory Syndrome: 2002–2003 (SARS) and Middle East Respiratory Syndrome: 2012-ongoing (MARS). SARS also had a zoonotic transmission in markets in Guangdong Province, China. It is said that COVID-19 is likely to have been transmitted from bats via palm civets. Similarly, MERS was also traced to zoonotic transmission of a novel coronavirus (likely from bats via dromedary camels) in Saudi Arabia. All three viruses have similar syndromes like fever and cough, which frequently lead to lower respiratory tract disease. However, SARS has a higher CFR of 9.6%, while MARS is even higher at a rate of 34.4%. Despite much higher CFRs for SARS and MERS, COVID-19 has led to more total deaths due to the large number of cases.

Projection shows a significant recession in the global economy due to Coronavirus spread [1]. The global surge reflects a new inflection point in this epidemic. Four 'major transmission complexes' (i.e., China, East Asia, Middle East, Europe) are now active, while the US is already at a tipping point. The analysis says that continued spread within established complexes plus community transmission in new complexes drives a ~0.3%–0.7% reduction in 2020 global GDP growth. The impact on demand slows down the growth of the global economy by between 1.8%–2.2%, instead of the 2.5% growth envisioned at the start of the year. Sectors are impacted differently. Certain sectors (e.g., aviation, tourism, hospitality) see lower demand for a longer duration. For others (e.g., consumer goods), demand is initially lower but expected to rebound quickly. The report also argues that 24th of February 2020 was a turning point, when the cases outside Chine exceeded in-China cases for the first time. South Korea, Italy, Iran, Japan and Singapore are the top five countries outside China which have reported a maximum number of cases, with Iran reporting the largest number of casualties outside China.

3. Data Source and Methodology

To focus on the key word "information", which is crucial for any invisible disaster, a series of different types of data were analyzed. Primary data sources include:

(1) Sina Weibo's (Chinese social media) hot search list (in which a key word has been accessed every day for how many times as well as how many hours) [5]

(2) Corona Virus timeline data in China (which are compiled by the authors from different data sources like Sina, Tiki-Toki, Caixin, Baidu, Tencent and provincial and municipal government data) [6–21]

(3) CSM media research data on the use of different types of media to acquire information [22,23]; and

(4) Mob-Tech Research Institute data of use of internet during the Corona virus spread [24,25].

Four specific types of analysis were made based on the above-mentioned data sources:

(a) **Timeline narrative, number of affected people and public concern**: The timeline narrative is developed based on the sequential events in the country, and important measures taken, which is also juxtaposed to the major public concerns. Weibo's data (2020) have been analyzed for the top 206 to 360 hits per topic (depends on the daily variation) over a period of three months, from 1 December 2019 to 1 March 2020 [24]. Tiki-Toki's data [9] is the Chinese government big data platform, and provides information on different government measures, news, policies, and also is linked to major global milestones in the related topic (here, Coronavirus-related topics). Sina's data was on (1) the number of affected people (confirmed cases, recovery, and death) at both the country level and in Hubei province, (2) Sina Weibo data to analyze social media information. Figure 1a,b show the growth in the number of affected and recovered people and casualties in Hubei province and the whole of China, which is referred to in a later section. Figure 2 was also prepared as an original diagram to highlight different phases of this disaster. Specific attention was made on the day to day changes in numbers, any significant policy actions taken, and any significant incidence (positive or negative) reported on social media or a website. Social media/website information (both government official sites as well private sites) were used to draw the timeseries narrative. Word Cloud analysis was made using the key words used in social media for all the five phases mentioned in the text, and the top five most commonly used words are picked to highlight the key discussion in the social media, as well as to understand citizens' agony.

(b) **Media use during/after Coronavirus spread and information types:** This is mainly derived from the analysis of [23] on February 20–21, 2020, with more than 1500 residents from all 31 provinces in China, to understand the use of media to acquire information related to Corona virus. The analysis used the data of CSM survey to draw original graphs and diagrams with its interpretation;

(c) **Positive impact on certain online industries**: The data from [24] are based on the analysis of 2019 and 2020 analysis, but more specific intensive analysis of the use of the internet during the period of 22 January 2020 to 6 February 2020. These data were used to understand the proliferation of certain online services compared to others, which is correlated to people's interest in different topics available online.

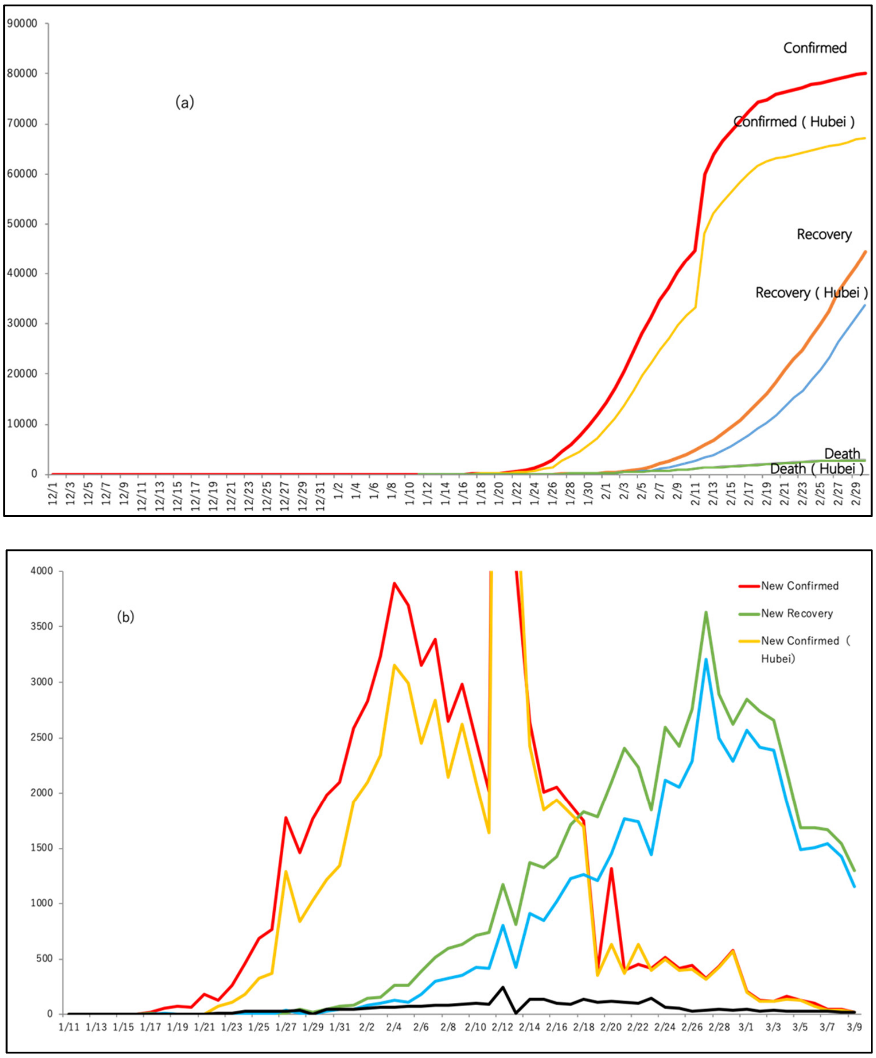

Figure 1. (**a**) Number of people affected, recovered, and dead in China and Hubei province; (**b**) New confirmed and recovered cases in China and Hubei province; (Source: these graphs were prepared by the authors using original data from: Sina News [5]).

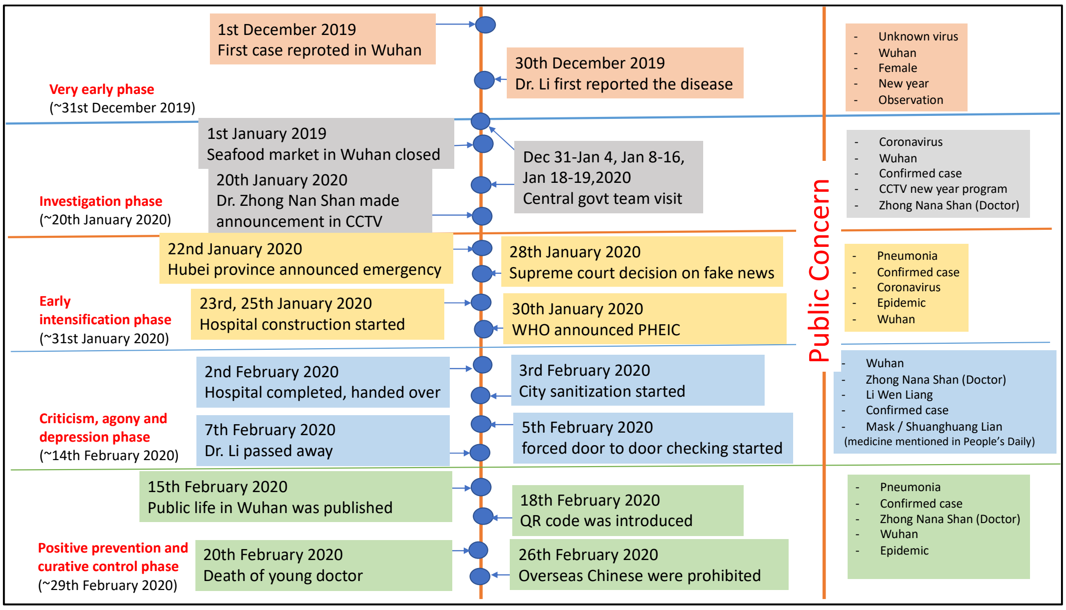

Figure 2. Timeline of key events and public concern; (Source: This figure was prepared by the authors using original data from: Sina, Tiki-Toki, Caixin, Baidu: [6–21]).

4. Data Analysis and Key Findings

4.1. Narrative on the Events and Its Response Sequence

To develop this narrative, as mentioned above, a large number of sources were consulted, reviewed and some milestones events are presented here. Needless to say, with a vast country like China, with the level of infection of Corona Virus, there are many small yet important events, which may be missed out here. However, the author tried to highlight the key developments in China based on the five following phases:

1. Very early phase: Until 31 December 2019;
2. Investigation phase: Until 20 January 2020;
3. Early intensification phase: Until 31 January 2020;
4. Criticism, agony and depression phase: Until 14 February 2020;
5. Positive prevention and curative control phase: Until 29 February 2020.

Figure 2 shows the timeline of key events in five phases. Authors extracted the key events from different news and social media reports. In each phase, five top public concerns are highlighted, which is prepared through word cloud analysis in each phase using the key social media data, as specified in the methodology section.

4.1.1. Very Early Phase: Until 31 December, 2019

As per the available statistics, the earliest case was reported on 1 December, 2019 in Wuhan, and thereafter sporadic cases have been reported all through December, especially in the later part of the month. The first case was reported in a paper [26] on 1st of December 2019. The health commission of Wuhan municipality reported the first case of Coronavirus (at the time, an unusual disease). These were unusual cases, which took the local physicians by surprise, and it was Dr. Li Wen Liang who reported the unusual case as a possible epidemic in WeChat social media on 30th of December 2019.

4.1.2. Investigation Phase: Until 20 January 2020

This phase was characterized by a crackdown by local government and detailed investigation. Huanan seafood market in Wuhan city was closed on 1st of January. The city government and its health commission investigated the cases in December and called Dr. Li and made him apologize for spreading a rumor on the 31st of December 2019. Three teams of experts from Beijing conducted a detailed investigation from the 31st December to 4th January, 8–16 January and 18–19 January. It was revealed that the disease was a new type of epidemic, which had not been reported earlier. This was announced on 20th of January by a major and well-known doctor, Dr. Zhong Nan Shan, in a CCTV online interview.

4.1.3. Early Intensification Phase: Until 31 January 2020

This was a critical period, when the disease spread was intensified and a relatively large number of casualties was observed. Figure 1a shows the number of people affected, recovered and dead in China and Hubei province, and Figure 1b shows the new confirmed and recovered cases in China and Hubei province. At an early part of this phase, a few critical and wise decisions were made:

22nd January: Hubei province announced a Level II public emergency;

23rd of January: Wuhan city was closed and all the entries and exits to the city were restricted. The decision to construct Huoshenshan Hospital (new hospital) for Corona virus cases was announced on this day (23rd January), followed the decision to construct Leishenshan Hospital (another new hospital) decision on 25th January. Ten hospitals in Wuhan city appealed for a supply of medical and other emergency goods from all over the country;

24th January: Hubei province followed the suit, and the whole province was closed for entrance and exit. Hubei, Beijing, Shanghai and eight other provinces declared a public emergency;

25th January: The Supreme court provided instruction on “Fake news” and the negative consequences of this. Tencent, which is the parent company of WeChat, established a website called “Rumors exposed website,” as a platform to reduce rumors;

26th of January: The first emergency supply arrived from Sichuan to Wuhan, along with medical and healthcare staff;

28th January: President Xi Xinping met WHO DG Dr. Tedros Adhanom Ghebreyesus and discussed the situation. China Media administration instructed all TV channels to reduce entertainment programs, and to increase broadcasting information and programs on Coronavirus and related news;

29th January: A countrywide emergency was declared;

30th January: The Emergency Committee on the novel coronavirus (2019-nCoV) under the International Health Regulations (IHR 2005) was reconvened by the World Health Organization Director–General Dr Tedros Adhanom Ghebreyesus on 30th January (Geneva time) and a Public Health Emergency of International Concern (PHEIC) was declared;

31st January: People’s Daily, the major Chinese newspaper’ official account, published fake news on a possible medicine (named Shuang Huang Lian, a Chinese antibiotic, of which online orders and users have drastically increased) for Coronavirus by mistake, which caused the panic-buying of the medicine by the public.

4.1.4. Criticism, Agony, Depression and Control Phase: Until 14 February 2020

The next phase was a phase of panic, criticism, agony and sad news. The following events took place that explain this phase:

31st January: Public criticism started on Chinese social media regarding the outbreak of the virus;

1st February: People’s Daily corrected their mistake regarding the fake news. A major media site, Caixin data analysis, showed that public agony had increased and people were growing worried about the future spread of the virus;

2nd February: The new hospital was prepared and handed over to the Army to take control;

3rd February: Sanitization of public spaces started, school entrance examinations were cancelled, and another new hospital was ready;

4–6th February: This was a time of control, where a few major control measures were taken. like a lockdown of villages, towns and cities (earlier, this was restricted to urban areas only). A new policy of "no one will be spared" was started (this enabled the government to enter people's house and check for virus symptoms). Dou Ban, a major media group, was shut down. Overseas news, especially the spread of Coronavirus in a cruise ship in Japan (Diamond Princess) was broadcast in China through different media;

7th February: The first whistleblower from Wuhan, Dr. Li, passed away, and this caused severe public criticism in social media. This was followed by a depression phase, where several suicides by the infected people were observed, to save their respective family members;

9th February: The Center of Disease Control (CDC) head gave an online interview with Caixin and announced that the virus is a totally new type, of which not much is known yet.

There were several incidences of sacking senior administration people; the China News head was sacked for spreading wrong information (12th February) and Wuhan's Mayor was replaced (13th February). Holidays (school as well as offices) were extended.

4.1.5. Positive Prevention and Curative Control Phase: Until 29 February 2020

The following phase was a time of positive prevention and curative planning. Several new initiatives were taken through media to address public criticism as well as to lessen public agony:

15th February: A diary of public life in Wuhan was broadcast and shared through social media;

18th February: A touching story of female nurses cutting their hair to cope with the continuous work with protective suits was broadcast in the mass media as well as on social media. Dead bodies post-mortem had started to identify the key medical factors and impacts on the body. On the 18th of February, a unique approach of using a QR code was adopted in Wuhan and then spread to other parts of Hubei province using mobility and safety of the person (in terms of effect of Corona virus). This QR code was used for public transport, entering public areas. Using big data in mobile phones, three color coding were used (Figure 3): green (safe), yellow (need to be cautious), and red (cannot enter). Printed QR codes were used for the people who did not have mobile phones (like elderly people or children). On 19th of February, the "no one will be spared" policy was ended.

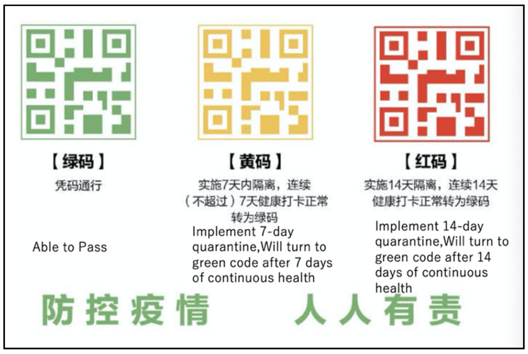

Figure 3. Three color codes used for monitoring people's movement (Source: https://www.sina.com.cn [5]).

20th February: A newlywed young doctor passed away, which also created negative sentiment in social media. The issues of vulnerable people like the aged population (11 of them died in an old people's home in Wuhan, along with the caregiver, which came out in the news on 20th February), physically and mentally challenged people, and their caregivers, received attention in the media;

21st and 22nd February: Data management and its authentication was re-ensured on (Jingzhou city), and goods distribution was re-investigated to ensure a balanced distribution (after a TikTok video which pointed out the imbalance in some areas). Punitive measures were taken for the two leaders of Hubei province for hiding information (22nd February);

23rd February: The last half of this phase was marked by mixed measures: ensuring the free flow of emergency goods and food and punishing those prohibited them (23rd February), and the death of two additional health professionals (23rd February);

26th February: New infection due to the return of overseas Chinese people in some selected provinces;

28th February: The unfortunate incidence of drinking sanitization tablet by mistake by some rural people, caused health issues, and there was another unfortunate incidence of suicide of a junior high school kid who did not have a mobile phone to undertake online classes provided by schools.

4.2. Media Use during/after Coronavirus Spread and Information Types

As mentioned above, an analysis was done by CSM Media Research with 1500 residents all over China on the mobile they use to access different sites. Figure 4 shows different media usage on four different aspects: increased usage after Coronavirus spread, same use as before, less use than before and do not use it for 6 months. Analysis shows that WeChat and TV played a strong role in acquiring information after Coronavirus spread. The amount of applications has also increased compared to other media usage, since it provides real-time information.

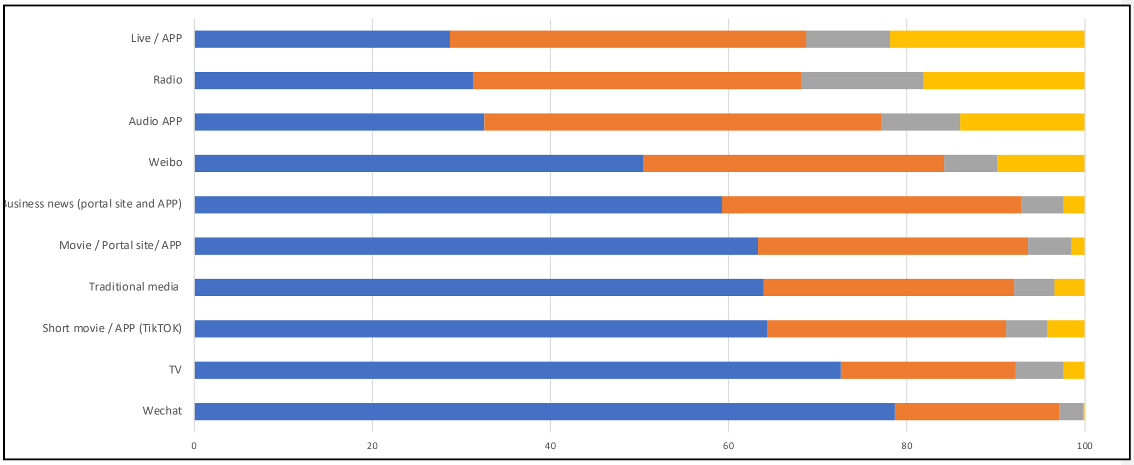

Figure 4. Use of different types of media before and after the Coronavirus spread; (Source: this figure was prepared by the authors using original data from: CSM Media Research [23]).

The survey also pointed out that 44% people sought to proactively secure information, followed the news and put in their favorites. A total of 33% viewed the information proactively, but did not put it into their favorite news items. A total of 19% people saw the information if it was in the news or media; 2% of people did not bother to take any additional actions for information gathering, while another 2% did not want to hear the negative news on Coronavirus.

Figure 5 shows the types of information accessed by different users through online platforms. It shows that the maximum access was to get information on medicines, followed by a set of other information like food/drink, online education, in-house sports, business information and entertainment and leisure goods. This shows the lifestyle requirements when people were isolated in their home for a long period of time.

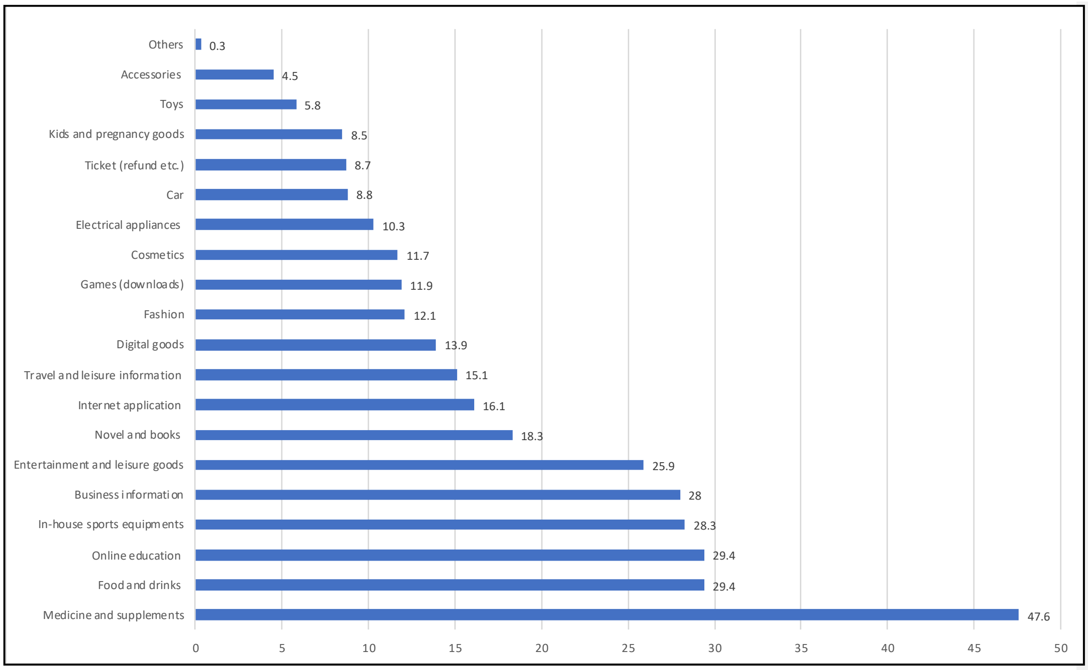

Figure 5. Types of information needed by people through online platforms; (Source: this figure was prepared by the authors using original data from: CSM Media Research [23]).

4.3. Positive Impact on Certain Online Industries

As seen in Figure 5, medicine, food supply and online education were the top searched items. Online food supply users have drastically increased by 10 million, with an increase of 10.60 million in delivery capacity (by volume) when comparing the data of online food shopping of January 2019 with that of January 2020. A significant increase is observed in users with the age group 35 to 44 years, from 27.9% (January 2019) to 45.1% (January 2020). Specific increase has been noted with households with children from 0 to 3 years old (from 7.2 % of January 2019 to 25.2 % in January 2020). The available data show that four major online food supply companies have increased their delivery capacity by a significant percentage. They are as follows: Hema Fresh (up by 50% compared to before the virus spread), Miss Fresh (up by 321% compared to January 2019), Dingdong Maicai (up by 300% from December 2019), and Jing dong Daojia (up by 470% compared to January 2019). All the companies are struggling with a lack of human resources and shared their employees to help each other, which delayed delivery in several cases.

Online education has also seen significant changes. On 27 January 2020, the Central Government Education Ministry has declared to postpone the start of classes until after the spring vacation. There was an instant rise in online education (Xueersi online internet school) after that, which saw a drastic increase by twenty-fold from 0.52 million to 11.54 million users within a period of one week (28 January to 6 February, 2020).

5. Key Learning and Postscripts

Through the Susceptible-Exposed-Infectious-Removed (SEIR) model and AI, [27] found that the epidemic of China should peak by late February, showing a gradual decline by the end of April. A five-day delay in implementation would have increased the epidemic size in mainland China three-fold. Lifting the Hubei quarantine would lead to a second epidemic peak in Hubei province in mid-March and extend the epidemic to late April, a result corroborated by the machine learning prediction.

WHO, in a recent joint study with Chinese colleagues, has summarized four specific key lessons as follows [3]:

1. China has rolled out perhaps the most ambitious, agile and aggressive disease containment effort in history. Although initially quite aggressive, gradually, a science and risk-based approach was taken to tailor its implementation;
2. Achieving China's exceptional coverage with adherence to these containment measures has only been possible due to the deep commitment of the Chinese people to collective action in the face of this common threat. At a community level, this is reflected in the remarkable solidarity of provinces and cities in support of the most vulnerable populations and communities;
3. China's bold approach to contain the rapid spread of this new respiratory pathogen has changed the course of a rapidly escalating and deadly epidemic;
4. China is already, and rightfully, working to bolster its economy, reopen its schools and return to a more normal semblance of its society, even as it works to contain the remaining chains of COVID-19 transmission.

From our own analysis, it was observed that the success of China's efforts in controlling the disease was a combination of strong governance, strict regulation and spontaneous community/citizen participation. Although it was a late response in terms of the local and provincial government at the initial stage, once the disease was confirmed as a new one, collective responses at the community, ward, city, province and national levels were significant. To keep this large a number of people confined in their homes for almost two months was not an easy decision in terms of both economic and socio-psychological aspects. China's mobile network and big data system was able to create the QR code-screening of people, which can be considered a significant achievement. As mentioned in the earlier part of this paper, WHO DG has termed this virus spread as infodemic; having the right information was key to the success of mitigation measures. At an early stage, The Supreme Court's directives on fake news were a very good step in this regard to reduce the spread of confusion and panic. The "Rumors exposed website" created by Tencent (the parent company of WeChat) helped to share information on fake news and rumors effectively. Whenever there was fake news published or some mismanagement happened with the emergency goods and food supplies, quick corrective measures were taken by the authorities. At the village level, local communities and volunteers worked hard to ensure the implementation of the mitigation measures to reduce the spread as well as to report confirmed or suspected cases. At an early stage, data management was an issue, but once the virus was confirmed and declared by the government, strict data management measures were put into place. In this case, strict corrective measures were ensured for the mismanagement of data. The current case needs a science based solutions with local action [28].

These lessons are also reflected in the WHO research roadmap [29], where eight specific research issues have been identified with a balance of medical diagnosis and community use. It also emphasized social science research in the outbreak response, where the WHO will establish a team that will be integrated within multidisciplinary research and operational platforms and will connect with existing and expanded global networks of social sciences. As per [30], governments will not be able to minimize deaths from coronavirus disease 2019 (COVID-19) and the economic impact of viral spread. Keeping mortality as low as possible will be the highest priority for individuals; hence governments must put measures in place to ameliorate the inevitable economic downturn. In our view, COVID-19 has developed into a pandemic, with small chains of transmission in many countries and large chains resulting in extensive spread in a few countries, such as Italy, Iran, South Korea, and Japan. Most countries are likely to have a spread of COVID-19, at least in the early stages, before any mitigation measures have an impact [30].

As we started the paper with two key words "humanitarian challenge" and infodemic, we would like to once again highlight that basic humanitarian principles need to be followed in this type of emergency. Of course, there are geo-political, economic and social consequences, which also need to be looked at. However, humanitarian issues need to prevail over other priorities. The second point is that Coronavirus is a non-measurable disaster, unlike other invisible disasters like radioactive emission. Therefore, having correct and timely information is crucial for stopping its spread, as well as in the curative prevention of this disease. These two factors, along with good governance and citizen participation, will hold the key to success in combatting Coronavirus in future.

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References

1. Mckinsey Coronavirus COVID-19: Facts and Insights. Available online: https://www.mckinsey.com/~{}/media/mckinsey/business%20functions/risk/our%20insights/covid%2019%20implications%20for%20business/covid-19-facts-and-insights-february-28-2020-mckinsey-vf.ashxorg (accessed on 11 March 2020).
2. Zaroncostas, J. How to Fight an Infodemic. Available online: www.thelancet.com (accessed on 11 March 2020).
3. WHO China. *Report of the WHO-China Joint Mission on Coronavirus Disease 2019 (COVID-19)*; WHO: Geneva, Switzerland, 2019.
4. Wu, Z.; McGoogan, J.M. Characteristics of and Important Lessons from the Coronavirus Disease 2019 (COVID-19) Outbreak in China in JAMA. *JAMA* **2020**. [CrossRef] [PubMed]
5. Sina News. Available online: https://news.sina.cn/zt_d/yiqing0121?wm=6122_1221 (accessed on 11 March 2020).
6. List of Websites Consulted: People Wang. Available online: http://www.people.com.cn (accessed on 11 March 2020).
7. XINHUA Wang. Available online: http://www.news.cn/whxw.htm (accessed on 11 March 2020).
8. CCTV News. Available online: http://news.cctv.com (accessed on 11 March 2020).
9. Tiki-Toki. Available online: https://www.tiki-toki.com (accessed on 11 March 2020).
10. Piyao Rumors Exposed Website. Available online: https://vp.fact.qq.com/home (accessed on 9 March 2020).
11. Chinese CDC. Available online: http://www.chinacdc.cn (accessed on 13 March 2020).
12. China Health Commission. Available online: http://www.nhc.gov.cn (accessed on 11 March 2020).
13. Wuhan Municipal Health Commission. Available online: http://wjw.wuhan.gov.cn (accessed on 11 March 2020).
14. Hubei Province Health Commission. Available online: http://wjw.hubei.gov.cn (accessed on 11 March 2020).
15. Baidu. Available online: https://voice.baidu.com/act/newpneumonia/newpneumonia (accessed on 11 March 2020).
16. Wechat Public Platform. Available online: https://mp.weixin.qq.com/ (accessed on 11 March 2020).
17. Sina Weibo. Available online: https://www.weibo.com/ (accessed on 11 March 2020).
18. Tencent News. Available online: https://news.qq.com (accessed on 11 March 2020).
19. Caixin. Available online: https://www.caixin.com (accessed on 11 March 2020).
20. South China Morning Post. Available online: https://www.scmp.com (accessed on 11 March 2020).
21. Changjiangwang. Available online: http://www.cjn.cn (accessed on 11 March 2020).
22. CSM Media Research. Available online: http://www.csm.com.cn (accessed on 9 March 2020).
23. CSM Media Research Survey Expected Survey Report on Consumer Media Consumption and Use during the Epidemic. Available online: http://www.csm.com.cn (accessed on 9 March 2020).
24. Mob-Tech Research. Available online: https://www.mob.com (accessed on 9 March 2020).
25. Mob-Tech Research Institute. Data Insights on Mobile Internet in Epidemic. Available online: https://www.mob.com (accessed on 7 March 2020).
26. Huang, C. Clinical features of patients infected with 2019 novel coronavirus in Wuhan, China. *Lancet* **2020**. [CrossRef]
27. Yang, Z.; Zeng, Z. Modified SEIR and AI prediction of the epidemics trend of COVID-19 in China under public health interventions. *J. Thorac. Dis.* **2020**. [CrossRef]

28. Future Earth. Emerging Viruses A Global Health Concern Requiring Science-Based Solutions And Local Action in Future Earth Knowledge Action Network. Available online: www.futureearth.org (accessed on 7 March 2020).
29. WHO. *COVID-19 PHEIC Global Research and Innovation Forum: Towards a Research Roadmap*; WHO: Geneva, Switzerland, 2020.
30. Anderson, R.; Heesterbeek, H.; Klinkenberg, D.; Hollingsworth, T.D. How will Country-Based Mitigation Measures Influence the Course of the COVID-19 Epidemic? Available online: https://www.thelancet.com/journals/lancet/article/PIIS0140-6736(20)30567-5/fulltext (accessed on 7 March 2020).

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COVID-19 Pandemic Response in Japan: What Is behind the Initial Flattening of the Curve?

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Abstract: The new coronavirus disease (COVID-19) emerged in December 2019 and became a global pandemic in March 2020. The unprecedented speed of SARS-CoV2 spread, the high infection rate among the aged population, and the collapse of healthcare systems in several countries have made COVID-19 the worst "modern" pandemic. Despite its proximity to China, a large aged population, and a high urban density, Japan has mitigated successfully the initial catastrophic impacts of COVID-19. This paper analyzed the key policy measures undertaken in Japan and suggests that Japan's culture, healthcare system, sanitation, immunity, and food habits, along with citizens' behavior, are the possible reasons for the successful flattening of the curve. Although additional disease peaks may occur, and a consequent increase in the number of affected individuals, a combination of policy, good governance, a healthy society, and good citizen behaviors' should be sufficient to provide enough time for the health care system to cope with them. Cluster approach, science-based decision making, and scenario planning were some of the key policy decisions taken by the government. Based on the lessons from Japan, this paper suggests the importance of an ecosystem-based lifestyle as a potential way to cope with pandemic events.

Keywords: cluster approach; scenario planning; expert advice; ecosystem approach; 3C approach (closed space; crowded space; close contact setting)

1. Introduction

More than four months have passed since SARS-CoV2, the etiologic agent of COVID-19, was initially reported in Wuhan, China in the first week of December 2019. It was officially brought to the government attention at the end of December, and upon evaluation by several teams of experts, it was recognized by the Chinese government as a new virus-borne disease in the third week of January 2020. The WHO announced it as a PHEIC (Public Health Emergency of International Concern) on January 30, 2020, and finally a global pandemic on March 11, 2020 [1]. Hua and Shaw (2020) provided a summary of the responses adopted in China in the first three months of the epidemic [2], while Shaw et al. (2020) provided insights on the initial responses followed in East Asia, focusing on China, Korea, and Japan [3]. The global chronologic status up to March 2020 has also been discussed [3].

The epidemiology of COVID-19 is constantly changing, and therefore, it is difficult to estimate an accurate disease incidence. In fact, 193 out of the 195 world countries have reported COVID-19 cases, and the number of affected people has soared to more than 7.2 million with more than 407,000 deaths as of 9th of June 2020 [4]. The hotspots of the disease have constantly changed: from China, it initially shifted to Iran, Italy, and South Korea, and then moved to other parts of Europe such as Spain, France, and the UK. The hotspot then changed to the USA, with the largest number of infected people and casualties. New hotspots are more recently found in Brazil and Russia with the second and third highest numbers of infected people. In particular, the case of Brazil is alarming in the sense that the daily new cases are rising in the range of 20,000 to 30,000. Recently, the Brazilian government has decided to change the reporting system, and exclude the accumulated counts. Russia, which currently has the third-highest global number of infected individuals has a presumably questionable low death rate (often termed as unreported death cases). Moreover, a new hotspot seems to be emerging in India, a country with a large population density, especially in the informal settlements. Altogether, this makes COVID-19 the worst pandemic in the modern age, after the Spanish flu, which occurred more than 100 years ago.

Shaw et al. (2020) pointed out that SARS-CoV2 (and COVID-19) has the following characteristics: (1) a high spread rate (and speed), (2) affects more severely the aged and immunocompromised people (the most vulnerable), and (3) is associated with differential recovery rates in different countries and age groups [3]. Although in most countries, the vulnerable populations are those above 65 and/or 70 years of age, the younger population, including those in their 20s, 30s, and 40s, are also affected. There are also many cases of asymptomatic infection, where an individual has not developed any COVID-19 symptoms but tested positive for the virus, potentially making COVID-19 (and its transmission) even more complicated. Thus, widespread testing is considered an important tool to detect affected people in most countries, followed by quarantine, physical distancing, and lockdowns, among others.

It should be noted that while the pandemic is global, the responses are local [3]. The specific response against COVID-19 depends on the country's governance system, regulations/ constitutional provision, capacity, the robustness of its health system, and, more importantly, culture and citizens' behavior. Therefore, every country has its own unique success/failure story, depending on its own local conditions. Even within one country, local governments (at state, province, or prefecture levels) have their own unique response mechanisms. Shaw et al. (2000) mentioned the importance of a multi-disciplinary approach to the COVID-19 response [3].

This study was not based on "pure epidemiological analyses". Rather, we attempted to understand the policy and behavioral responses in Japan, locating them in the COVID-19 timeline, as well as the implication of the emergency announcements in the country. For a detailed analysis of government action, we refer to earlier publications [3]. The core part of the paper provides an analysis of the inherent socio-political system in Japan, along with its people's behavior and immune status. An attempt was also made to highlight the ecosystem-based approach as a potential future lifestyle. This paper is intended for a wider audience who work in the environment, disaster, and development fields, particularly those who study possible ways to address biological hazards. We need to emphasize that the results are not supposed to be compared with how the other countries flattened their curves. We all understand that the "pandemic is global and its responses are local". So, keeping in mind the local response issues, this paper demonstrates the example of Japan.

2. History of COVID-19 in Japan and Basic Policies and Measures Applied

The first case of COVID-19 was reported in Japan between January 10 and 15, 2020: a Chinese national who traveled to Wuhan. The proximity of Japan to China, the high travel volumes between the two countries, the high percentage of aged individuals in Japan, a high population density in urban metropolitan areas such as Tokyo and Osaka, and high volumes of commuters in these major cities made Japan especially vulnerable to this pandemic (in theory). However, in spite of these vulnerabilities and the expected higher exposure rates, the country has been able to suppress the initial spread of the disease by flattening the curve and reducing the number of contagions and deaths.

Figure 1 shows the basic concept of Japan's response to COVID-19 [5–7]. While most of the countries experienced high increases in the number of affected people and fatalities, Japan has been able to limit its initial outburst. As of June 7, 2020, Japan had reported more than 17,000 cases, of which 910 individuals died [5]. Although some criticize and point out that Japan has not done enough testing, and that the number of infected cases may be higher than the officially reported, the death statistics confirm the initial flattening of the curve. In this section, some key countermeasures adopted in Japan are discussed within the respective timeline.

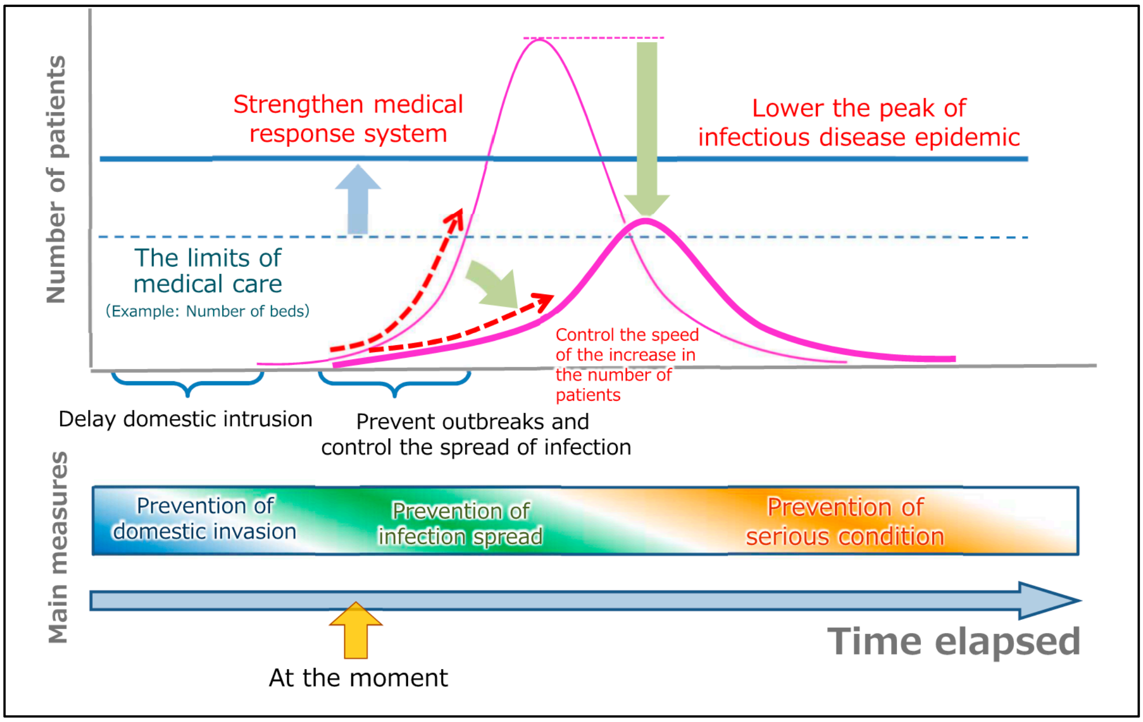

Figure 1. Illustration of Japan' COVID-19 response (source: [6,7]).

Shaw et al. (2020) [3] and Wiki (2020) [8] provided analytical overviews of the responses and key approaches adopted in Japan, such as border control measures (*Mizugiwa Taisaku* in Japanese), a cluster approach, an expert committee's scenario planning, and overshooting challenges, among others. Three main potential phases were considered in these approaches: 1) prevention of domestic spread, 2) prevention of the spread of infection, and 3) prevention of serious spread. It seems that Japan is currently in the third phase, which aims to prevent serious illness from occurring. The key target of this approach was to reduce the number of affected people by lowering the peak and strengthening the medical system. This is crucial to prevent outbreaks and control the speed of infection, so as to provide enough time for the medical facilities to be prepared. This was done by strengthening other countermeasures such as border control, identifying key clusters, closing schools, promoting telework, and avoiding large public gatherings (e.g. cancel key sports events and festivals such as the cherry blossoms' viewing). To maximize the efforts to suppress transmission and minimize socio-economic damage, the following three steps were taken:

(1) early detection of and early response to clusters, (2) enhancement of intensive care responses via securing medical service systems for severely ill patients, including medical equipment (Ventilator, ECMO, etc.), and (3) enforcement of citizens' behavioral modification [7].

Japan focused mainly on detecting and control the clusters of infection and performed selective testing for the virus, under the rationale that to end the epidemic quickly, it was extremely important to prevent one cluster from developing into another cluster. It was also important to curtail the rate of increase of cases (and patients) as much as possible through these preventive measures, in order to control the epidemic in Japan [7]. This was effective at an early stage, however, in the longer run, it failed to prevent the disease spreading. One-third of Tokyo's cases in late March and early April were linked to sports clubs, pubs, and other night entertainment establishments, where cluster tracing is difficult [9]. However, this gradually decreased with the announcement of a national emergency, which we better describe in the next section. Meanwhile, compliance with calls for remote working and social distancing has been weak. In fact, it is argued that many Japanese companies were not equipped (and prepared) to adopt remote working schemes. Furthermore, the relatively smaller houses in urban areas, where the space to work is limited was also a condition. Moreover, public transportation operated as normal, although certain routes have reduced their number of trains or buses.

As for immigration restrictions, Japan's response was slow. The US, the Philippines, Singapore, Indonesia, Vietnam, and Taipei adopted quarantine measures that were implemented soon after Wuhan was locked down, from January 23, 2020 [10]. Travelers who visited Wuhan within the past 14 days were prohibited from entering these countries. On the opposing side, at that time, Thailand and Cambodia did not restrict immigration. In contrast, in Japan, the government took a weak measure and prohibited the entry of people who had stayed in Hubei, China in the last 14 days (from February 1st, 2020). The government also prohibited the entry of people coming from 73 countries/regions in the April 2nd, 2020 [11].

Figure 2 provides a timeline analysis of Japan's response to COVID-19. Japan's response can be divided into five major phases: (1) the containment phase, (2) the medical service reinforcement phase, (3) the mitigation phase, (4) the emergency phase, and (5) the recovery phase. Each phase is characterized by certain policy measures. During the containment phase in January 2020, the key focus was to reduce the number of visitors from the key affected areas in China, including Wuhan. Immediately after China declared the new virus and the WHO's announced COVID-19 as a public health emergency of international concern (PHEIC), Prime Minister Abe announced COVID-19 as an infectious disease under the Infectious Disease Control Law on January 28, 2020, and a COVID-19 headquarters was established in the Prime Minister's Office on January 30, 2020, including senior bureaucrats from different key ministries. In addition, during this phase, the luxury cruise ship Diamond Princess docked in the Yokohama harbor, and several new COVID-19 cases were reported. The initial decision-making and response of the COVID-19 headquarters focused on managing patients on the Diamond Princess as well as developing strategies to reduce the disease spread in the country.

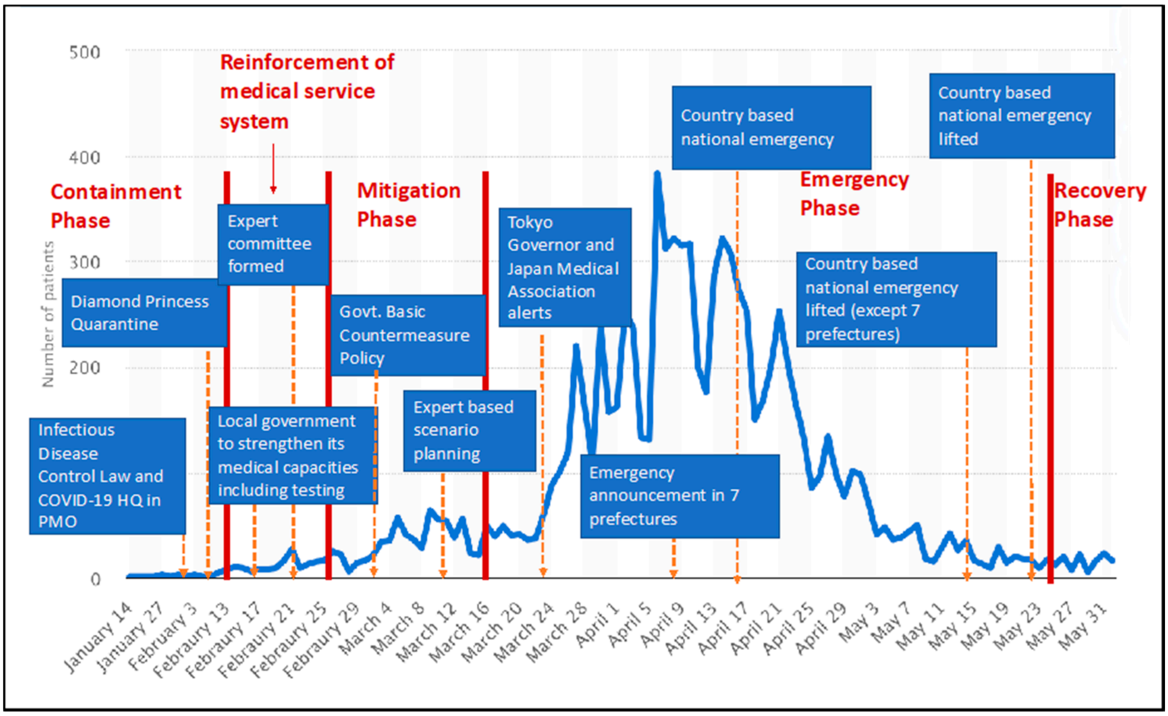

Figure 2. Timeline of the COVID-19 response in Japan with the specific policy measures adopted (source: authors based on data from [12]).

The analysis of the number of secondary transmissions caused by a single infected person, based on the relevant cases, revealed that the number of secondary transmissions was significant in cases where the root of infection was a closed space with poor ventilation [7]. During the following phase (medical service reinforcement phase), mainly in February 2020, the emphasis was placed on the strengthening of the medical care system. Local governments were instructed to strengthen their medical capacity and to increase the testing capacity. On February 16, 2020, the Ministry of Health, Labor, and Welfare worked with local governments to establish 536 consultation centers that covered every prefecture within the country to provide concerned citizens with instructions on how to get tested for COVID-19 and receive treatment, if needed.

Not long after, Prime Minister Abe convened the government's first Novel Coronavirus Expert Committee Meeting at the Prime Minister's Office to draft the national guidelines for COVID-19 testing and treatment. The expert committee brought together ten public health experts, medical professionals, and data scientists from across Japan to coordinate a response to the virus with Abe and the government's coronavirus task force in a roundtable format.

The mitigation phase started with the establishment of the Basic Countermeasure Policy for COVID-19 on 25 February 2020, based on suggestions from the expert committee. On 27 February 2020, Prime Minister Abe requested the closure of all schools from 2 March 2020 until the end of spring break, in early April. The next day, the Japanese government announced plans to create a fund to help companies subsidize workers who needed to take time off to look after their children. On 27 February 2020, the Japanese government announced plans to expand the national health insurance system so that it would cover COVID-19 testing. The key characteristic of this phase was the close cooperation of the expert committee and government decision-making. The expert committee developed detailed scenarios with different levels of uncertainties and calculated the required percentage of physical distancing. Data science played an important role in these models. These scenarios were used to design specific mitigation measures. One of the difficulties of COVID-19 response in Japan is the approximate 12–day delay between the diagnosis and its registration in the official statistics [6]. Therefore, for better accuracy, human mobility via mobile phone data as an early indicator of confirmed cases was also explored [13]. For instance, NTT DoCoMo data and high-resolution hourly population data of Mobile Kukan Toukei within Tokyo were analyzed [13]. The dataset divided Tokyo into 8500 grid cells of 0.5 km $\times$ 0.5 km. The preliminary analysis suggested that the mobility levels correlated with the daily growth rate of confirmed cases within the following 12 days. On 9 March 2020, the Health Ministry published a disease forecast for each prefecture and instructed their local governments to prepare their hospitals to accommodate the estimated patient numbers. Furthermore, it was predicted that the virus peak in certain prefectures (such as Tokyo, Osaka, and Hokkaido) would occur three months after their first reported case of local transmission.

In the next phase (Emergency Phase), to provide a stronger legal basis for COVID-19 countermeasures, the National Diet passed an amendment to the "Special Measures Act to Counter New Types of Influenza of 2012" on March 13. The new act allows the Prime Minister to declare a "state of emergency" in specific areas where COVID-19 poses a grave threat to the lives (and economic status) of residents. On 30 March 2020, the Tokyo Governor requested its residents to stay at home for the next two weeks. The Japan Medical Association, in a press conference, expressed their concern on the current infection spread rate and advised the Prime Minister to declare a national emergency. On April 7, Prime Minister Abe called for a national emergency for one month in the seven most affected provinces effective from 8 April 2020. The national emergency was later extended to cover all of Japan on 16 April 2020. On May 14, the emergency phase was over in most prefectures (except in Tokyo, Kanagawa, Saitama, Hokkaido, Osaka, Hyogo, and Kyoto). Finally, on 25 May 2020, the national emergency was lifted in the whole country.

From all of the abovementioned, the key points of Japan's policy responses are [7]: (1) provision and sharing of information (call for self-restraint on travel and going out), (2) surveillance and information gathering (identifying carriers, strengthening testing systems, and continuing to develop rapid test kits), (3) pandemic prevention (declaration of the state of emergency, and its extension), (4) medical care (3C approach (closed space, crowded space, closed contact setting) and PCR testing), (5) economic and employment measures (new fiscal boosting), (6) other important considerations (procurement of essential goods, give relevance to social functions, preventing core government staffs from being infected). In the recovery phase, there has been a very strong focus by the government on the economy. A fiscal stimulus package, of 108.4 trillion Japanese Yen ((1.01 trillion USD), which is equivalent to 20% of the national GDP, was approved. Furthermore, there was a supplementary addition of 16.8 trillion JPY, which brought the total package to 117.1 trillion JPY.

3. Emergency Law in Japan and its Implications

Japan's emergency law is unique and different from that of other countries. The law does not allow the government (national or local) to enforce lockdowns. However, the head of the government (Prime Minister and governors) can appeal to the people to stay at home and request stores and other high-risk facilities to close. There is a delicate line of power between "request" (Yosei in Japanese) and "demand"' (Kyosei in Japanese). The 3C approach (closed space: Mippei in Japanese; Crowded space: Misshu in Japanese; Close contact setting: Misshu in Japanese) was (and is) emphasized during the emergency period. This means that people need to follow stay at home orders, avoid crowded places, and avoid close contacts.

During emergency periods, governors of the affected areas will receive the following powers: (1) instruct residents to avoid unnecessary outings unless they are workers in essential services such as healthcare and public transportation; (2) restrict the use of or request the temporary closure of businesses and facilities, including schools, social welfare facilities, theaters, music venues, and sports stadiums; (3) expropriate private land and buildings for the purpose of erecting new hospitals; and (4) requisition of medical supplies and food from companies that refuse to sell them, punish those that hoard or do not comply, and force firms to help transport emergency goods. These powers enable governors to take certain legislative actions. Mayors as well as town and village heads, have less autonomy but can appeal to the prefectural governor who can then make final decisions. For instance, in order to secure adequate supplies of medicine and other necessary goods, governors can fine uncooperative businesses involved in their distribution. Prefectures can also appropriate land and buildings for use as temporary medical facilities without the agreement of the owners, if necessary. Furthermore, the governors' non-legislative initiatives can include strongly urging people to avoid unnecessary travel as well as crowded spaces such as bars, nightclubs, restaurants, and karaoke boxes, pressing for sports and cultural events to be postponed or canceled, and asking people to refrain from using school facilities.

Thus, in Japan, a forced lockdown is not possible by law. Therefore, people's behavior and self-consciousness are extremely important for the flattening of the COVID-19 curve. During an emergency, repeated requests from governors, ministers, and the prime minister as well as experts' advice, are conveyed through the media sources. This has a large impact on people's behavior. At the local level, citizen/voluntary organizations played an important role in raising awareness for maintaining "social distancing"' and avoiding crowded areas. In addition, after the national emergency was lifted in the third week of May, some of the local governments remained vigilant and prepared to act quickly. For instance, the Tokyo Metropolitan Government, issued Tokyo alerts whenever the number of new affected cases reached double-digits (24, 22, 18 in three consecutive days), and interdicted (using red-colored symbols) Tokyo venues such as the city hall and the rainbow bridge. Additionally, other local governments such as the one from Kitakyushu city alerted its residents and requested the care for self-restraint, whenever new cases in the range of double-digits were reported on consecutive days in the city.

We believe that the governance and policy actions followed in Japan should be looked at and can be adopted in other countries, especially with respect to science-based decision making.

4. Characteristics of Japanese Lifestyles and Their Possible Implications

In this section, we argue that a combination of factors such as Japan's basic health policy, people's health consciousness and basic sanitation practices, food habits, and immune statuses enabled the flattening of the COVID-19 curve, ultimately reducing the number of resulting deaths. Although Japan has not conducted extensive coronavirus testing in comparison to other countries, we discuss the reasons for this decision, describing several hidden and unique aspects of this particular country.

4.1. Culture

Japan has a different greeting culture from other countries, and social distancing is normal. Maintaining good social distancing, including avoiding groups of people and maintaining a physical distance from strangers, may help prevent infections from spreading. Unlike Western countries, the Japanese do not have the custom of kissing on the cheek or hugging as a greeting. The Japanese hardly make any physical contact with friends or family while greeting them. Japan holds social isolation practices, even in densely urbanized areas [14]. As for greetings, Japanese often bow and sometimes shake hands. Thus, the country's culture is geared around maintaining a personal space [15].

Furthermore, Japanese people who are sick with cold, flu, or allergies normally wear surgical masks in public to prevent others from getting sick. This behavior is based on the "Japanese collectivism" in comparison to the "American individualism" [16]. Therefore, Japanese people do not have emotional resistance to wearing masks, whereas people in other countries are reluctant to wear them daily. Although recent psychological studies suggest that the theory is not applicable to young Japanese people [17], this tendency does not directly reflect the COVID-19 response. However, the number of infections under 40 years of age is increasing owing to unnecessary night outings. The only approach to tackle this issue was the closure of night clubs, bars, and restaurants enforced by prefectural governors in the context of a national emergency. Of note, the government provided economic compensation based on the size of the business affected. Moreover, most of the restaurants in the residential neighborhoods started "take-out" systems instead of serving the meals in the restaurant.

In contrast, some young Japanese citizens also cooperate, but based on self-interest [18]. In these cases, the behavior of wearing masks is based on not contracting the cold or flu virus from others. Regardless of whether their behavior is based on collectivism or self-interest, the more important message here is that wearing a mask can also signal others to keep their distance.

4.2. Healthcare System

Japan has a prominent health care system that provides universal health coverage. Japan has introduced the National Health Insurance (NHI) system in 1961. The NHI ensures that all citizens are provided with essential healthcare, regardless of preexisting conditions or economic status; free access, meaning patients are free to choose any hospital nationwide; and high-level care at low cost since the system is maintained with the use of public money [19]. In Japan, patients usually receive a plethora of tests when treated for even nonserious health problems, which are covered by the NHI. According to Japanese criteria for COVID-19 [20], if a person has any of the following symptoms they should first contact a coronavirus consultation center:

(1) Cold symptoms and/or a fever above 37.5 C, which lasts for 4 days or more,
(2) Elderly or those with preexisting health problems,
(3) Heavy physical fatigue or trouble breathing.

As for the number of tests (and confirmed infected individuals) in Japan, Japan has run so few tests because the Ministry of Health, Labor and Welfare initially chose PCR (polymerase chain reaction) testing not as a "medical procedure," but as a tool for "epidemiological investigation" to curb the outbreak spread [20]. As per the regulation, when a condition is under epidemiological investigation, it cannot be covered by the NHI; however, later when PCR was included as a medical procedure, it was possible to use the NHI. The expert panel advising the government mentioned that the "overwhelming" shortage of personal protective equipment for sample collectors and laboratory technicians has been one of the factors behind a slow pickup in PCR tests. However, as of 10 May 2020, the permission process is complete to start immune-based tests, which are simpler and quicker to conduct than PCR tests.

On the other hand, Chest CT is used for the diagnosis of COVID-19 (before PCR testing) although lung ultrasound rivals CT imaging for fast and accurate bedside diagnosis and monitoring of coronavirus infection. Ai et al. (2020) suggested that chest CT has a high sensitivity for the diagnosis of COVID-19 [21]. The stocked number of CTs in Japan is 107.2. million, and the average of OECD is 25.4/million. Thus, Japan probably conducts four times more Chest CT per patient than in other countries. As a result, the number of PCR tests related to COVID-19 was lower.

4.3. Sanitation

UNICEF highlighted the importance of handwashing as a preventive measure for COVID-19. Japan is the world's largest donor in the water and sanitation sector based on its experience, knowledge, and technology [22]. In Japan, the Ministry of the Land, Infrastructures, Transport, and Tourism (MLIT) manages offsite sanitation (sewerage and wastewater management), while the Ministry of the Environment (MOE) manages on-site sanitation (johkasou, septage management with scheduled desludging, and sludge treatment facilities) [23]. Owing to such technical achievements in sanitation, people can easily access clean water and drinking water. In addition, as for the individual behavioral level, the Japanese have educated handwashing with soap habits in their homes and schools since a tender age, and all people living in Japan have easy access to soap [24]. In this custom, the Japanese wash their hands after going to the toilet, returning home, meals, etc. According to a survey of the MHLW, 85.6% of respondents answered that they wash hands, gargle, or use hand sanitizer for coronavirus prevention [25]. In contrast, according to UNICEF, in the world, 40% of people (about 3 billion) do not have basic handwashing facilities at home. Moreover, over one-third of primary schools in the world (over half in developing countries) do not have handwashing facilities for children [24].

In Japan, not only soap but also hand sanitizers, ant-bacterial sprays, and rubbing alcohol are popular. They are set up everywhere, such as in front of the entrance of a building and near the bathrooms. Another sanitation behavior is the regular gargling of the throat. In other countries, it is considered a vulgar behavior, and there has never been any custom of doing it. In contrast, gargling is commonly seen in Japan as a helpful habit to prevent sickness. The custom of gargling to prevent sickness goes back centuries to the Heian Period, which lasted from 794 to 1185 [26]. In Japan, gargling is considered one of the two common-sense ways of not getting sick during the winter, along with washing hands. Satomura et al. (2005) showed that simple water gargling is effective in preventing upper respiratory tract infections [27]. This virtually cost-free modality would appreciably benefit the general population and contribute to reducing the risk of infection.

4.4. Food Habits

During meals, the Japanese do not usually eat by hand, but often use chopsticks. People in western countries also use knives, spoons, and forks, but they frequently use their hands, particularly when eating junk food (hamburger, sandwich, pizza, etc.). Eating by hand without washing hands increases the risk of infection. There are many fast-food chains in Japan, but most of the shops and restaurants serve hot wet towels with meals, and people can easily wipe their hands. It is a unique Japanese custom.

As for food habits, the Japanese prefer a traditional dish style of one soup and two side dishes served in small plates, compared with meat-oriented diets in western countries. These side dishes play an equal role as the main dish in providing sustenance and making the meal more appetizing. For side dishes, fermented foods are often used (such as soybeans (e.g., miso, soy source, natto), Japanese sake, and pickles). Fermented foods contribute to improved immune system function, prevent intestinal afflictions, and promote good health via the maintenance of a well-balanced gut microbiota composition [28]. In this sense, many traditional Japanese foods are filled with antioxidants, vitamins, minerals, and even beneficial bacteria. For example, miso is a fermented soybean paste that is a culinary pillar in Japanese food flavoring. Miso is a great source of probiotics or beneficial bacteria, which increases the health of the gut and enhances the immune system by providing high protein and mineral amounts, such as manganese zinc, vitamin E, vitamin K, various B vitamins, and folic acid [29]. Natto was also reported to contribute to healthy gut flora [29]. Furthermore, bacteria in Japanese pickles were shown to boost the immune system and prevent flu [29]. Matcha was consumed in Japan long before it was a trending latte flavor— it was first introduced from China by a Japanese Buddhist monk in 1191 [29]. Matcha is packed with antioxidants up to 137 times more than other types of green tea, which helps to reduce cell damage and fight chronic diseases [29]. In addition, seaweeds (e.g., nori, wakame, and aosa) affect bacterial infections [30]. In fact, edible seaweeds were reported to have an active principle which may help to defeat COVID-19 [31]. Drinking matcha may also help protect against heart disease by lowering "bad" cholesterol and increasing metabolism.

The Centers for Disease Control and Prevention (CDC) mentioned that the deterioration of the immune system by chronic health conditions, especially in the elderly, complicates coronavirus infections [32]. Although there is no evidence that attests to the effect of fermented foods on COVID-19, taking fermented foods impacts our guts and promotes health.

4.5. Immune System

Coronavirus has mutated into two strains, the “S-type”’ is older and appears to be milder and less infectious, while the “L-type”, which emerged later, spreads quickly and currently accounts for around 70% of cases [33]. Japan did not strictly restrict travelers from China during the first outbreak. As a result, the new infections caused by the “S-type” coronavirus spread first in Japan. Fortunately, this expansion may have been important to confer a degree of collective immunity against the “L-type” coronavirus that emerged later [34]. Although there are controversies, this relates to inherent immunity statuses, as per some scholars [35]. Nishijima et al. (2016) found that the composition of the Japanese gut microbiome contains greater Actinobacteria, particularly Bifidobacterium [35]. They also found that while there are a large number of carbohydrate metabolism microbial functions, there are few related to replication, repair, and cell motility. The analysis also showed that hydrogen, primarily used for methane generation in individuals from other countries, is primarily used for acetic acid generation in Japanese individuals. The enzyme responsible for the hydrolysis of polysaccharides in nori and wakame (edible seaweeds) was found in approximately 90% of Japanese individuals as opposed to 15% and under of individuals from other countries [35]. These findings suggest that the beneficial traits of Japanese people’s gut microbiomes may condition potential resistance to infections. This evidence may explain why the number of Japanese COVID-19 cases is rather low. Table 1 summarizes six aspects of Japan’s uniqueness making a parallel to overseas contexts.

Table 1. Six aspects of Japanese uniqueness (versus overseas).

Aspect / Factors	Japan	Overseas
	1. Government Response	
Lockdown	No, but declared a state of emergency for seven prefectures that then evolved to a nationwide emergency state	Yes
Immigration restrictions	Yes	Yes
Remote work	Applied	Applied
Closing schools	Applied	Applied
	2. Culture	
Greeting	Bow, sometimes shake hands	Shake hands, hug, Cheek kissing
Social distancing	Moderate	Low
Wearing a mask	No emotional resistance - affected person - allergic person (seasonal/ spring)	Emotional resistance
	3. Health Care System	
National Health Insurance Program	Universal (for all people)	Regional disparities
Medical system (guideline for COVID-19, CT scan, etc.)	Available with detailed guidelines	Available
PCR No. of CT [36]	After CT scan 107/million	Following diagnosis OECD: 25/million
	4. Sanitation	
Basic handwashing with soap	Educated since childhood Frequent	Regional disparities Washing hands after toilet [37]: Italy 57%, UK 75%
Gargling throat	Educated since childhood	Not common
Hot water bathing	Japanese custom Almost all houses have a bathtub	Shower instead of immersion bath
Ventilating a room	Open window	Air conditioner
Disinfection gel	At the entrance of a building or in a washroom	Regional disparities
Wet towel	Served when eating out	Served rarely
	5. Food Habits	
Eat seaweeds	Yes (marine algae, marine plants)	Rarely
Eat fermented food	Yes (miso, soy source, *tsukemono)* *something that includes lactic acid bacteria*)	Few (e.g., yogurt, cheese, beer, wine) but a different type of Japanese foods
Cutlery	Chopsticks	Folk, knife, spoon, but sometimes use hands
	6. Immune System	
Spread type of COVID-19	S-type spread from China earlier than L-type, generating partial resistance	L-type spread
Intestinal environment	About 90% of Japanese have intestinal flora with genes for enzymes that disassemble dietary fiber in seaweed	Less than 15% have genes found in Japanese population
Response measure	Individuals take action to enhance their immune system	Depend on immunological mechanisms of vaccination

5. Discussion

The COVID-19 outbreak reminds us of how an ecosystem-based lifestyle is important for modern people. Planetary and human health are not separable. Sustainable development, even in the context of an outbreak requires the integrated recognition that the environment and society are closely linked. There have been several arguments and discussions on ecosystem-based recovery, and how COVID-19 has urged us to become increasingly environmentally friendly. The economy recovery after COVID-19 should invest in nature, as a key focus. Within the framework of the Sustainable Markets Initiative under the leadership of His Royal Highness the Prince of Wales, a 10-point action plan to create a circular bioeconomy was proposed [38]. The 10-point actions include: (1) aim at sustainable wellbeing, (2) invest in nature and biodiversity, (3) ensure an equitable distribution of prosperity, (4) rethink holistic land, food, and health systems, (5) transform industrial sectors, (6) reimagine cities through ecological lenses, (7) create an enabling regulatory framework, (8) bring purposeful innovation to the investment and political agenda, (9) ensure access to finance and enhance risk-taking capacity, and (10) intensify and broaden research and education.

In Figure 3, the concept of the relationship between geo-, eco-, and socio-environment is illustrated comparing Japan and overseas contexts. Of note, this comparison does not intend to prove the superiority or inferiority of any country; it rather demonstrates two different sets of cultures, customs, habits, governance, etc. The concept of the earth has been dominated by Cartesian philosophy, where the typical phenomena include urban structures and gardens in cities. Modernization is generally based on the logic of logos, from Greek philosophy, whereas Asian philosophy is based on the logic of the lemma from Buddhism [38]. In Asia, including Japan, unprecedented disasters occur, and people have seen their society dominated by nature firsthand. Natural factors, as well as social factors, can cause disasters, and these two aspects are intertwined.

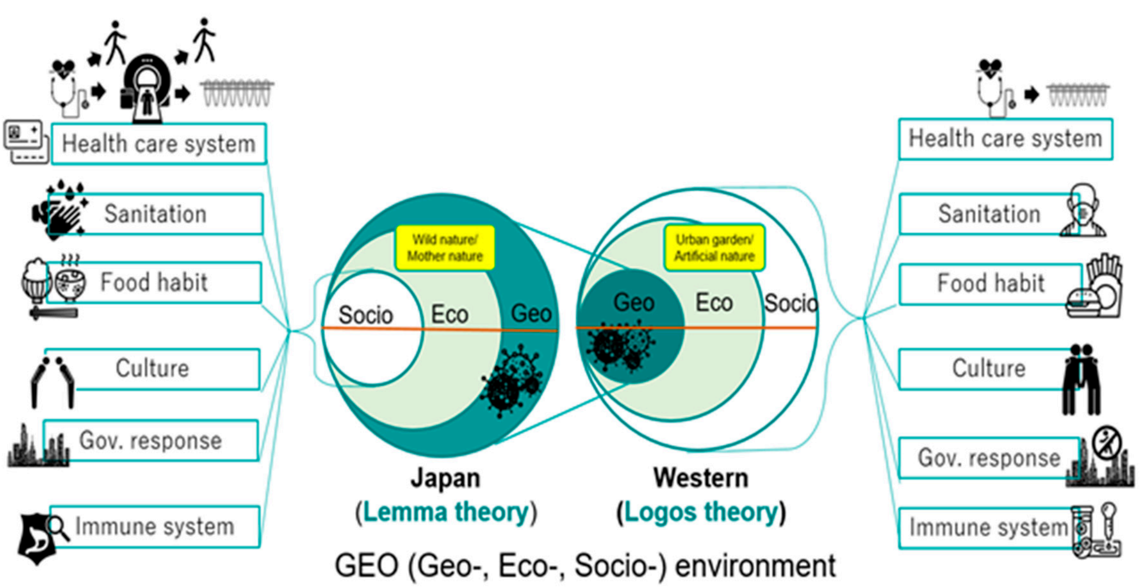

Figure 3. Relationship of the geo environment in Japan versus overseas countries.

The geo-environment has larger dimensions of climate change and natural disasters such as earthquakes, floods, droughts, and typhoons. The eco-environment governs the law of ecology (e.g., ecosystem services, functions, and services). The social environment refers to the rules of society govern (e.g., human wellbeing) [39,40].

According to Hagihara (2008), human wellbeing consists of three hierarchical levels in ecosystem health: the first level includes income, health, and a safe environment (e.g., lifeline, infrastructure, transportation, no pollution); the second level satisfies a convenient and comfortable environment (e.g., comfortable transportation, housing, green vegetation, and clean water); and the third level includes the realization of a meaningful life and fulfill communication, enjoying pastime and a flourishing natural environment (e.g., rich surrounding in close contact with community or relationship) [40].

The COVID-19 pandemic caused an unexpected shift in environmental health [41]. Owing to less traffic, decreased tourism, and industry shutdowns, polluted canals have transformed into waters clear enough to see fish swimming below in many countries [42]. Global air pollution has decreased after the outbreak owing to the lack of anthropogenic activities [42]. The International Union for Conservation of Nature (IUCN) has reported that COVID-19 could help save endangered species in China [43]. After the COVID-19 outbreak, many more people around the world have realized that many animal species have been adversely affected by humans [40]. COVID-19 may not be removed completely, it may appear again next year, and ultimately with the vaccine, it may become similar to other seasonal diseases such as influenza.

Madrodieva and Shaw (2020), in their analysis of Society 5.0 in Japan, have emphasized a human-centric society where technology connects people and tries to reduce the barrier of the digital divide [44]. Japan has taken steps towards developing definitions, principles, and standards for the focus areas of Society 5.0 and is considering proposing the devised standards to ISO to promote them in the international community. Healthcare and disaster prevention are the two key pillars of Society 5.0. It is envisaged that the futuristic society should focus on human and nature-centric approaches and policies while leveraging new technological innovations. In the case of Japan, we reviewed the current lifestyle and how actions were taken to shift from a modern lifestyle to a new optimal lifestyle, coping with the outbreak.

The successful integration of biological hazards into disaster risk reduction and response planning can be achieved if the following two goals are reached: (1) flattening the curve and enhancing the capacity of the healthcare system to achieve a better initial response; and (2) preventing and minimizing negative impacts on people (lives and livelihoods), socio-economic sectors, and development goals. Shaw et al. [45] in their recent review suggested ten steps for achieving these two goals. The ten steps are: (1) integrated surveillance and early identification and detection, (2) identification of hotspots/clusters at an early stage, (3) multi-disciplinary science-based decision support, (4) worst-case scenario planning, (5) inclusive (leave no one behind), human rights-based response and recovery planning, (6) trans-boundary and regional collaboration, (7) use of new and emerging technology, (8) public-private-people collective partnerships, (9) responsible media coverage and addressing fake news, and (10) transparency in information sharing. Japan's experience has shown the path for most of these steps for the initial response and the flattening of the curve. A successful recovery will depend on inclusiveness in recovery planning and transparency in sharing information in the future courses of action.

6. Conclusion

Although pandemics are global events, the responses to them are always local [3]. The purpose of this paper was not to compare the Japan case with those of other countries, but to highlight some of the key lessons that can be applicable to other countries where the infections are steadily growing. Shaw et al. [3] have argued that governance, technological application, and citizen behaviors are some of the key aspects that could flatten the curves in China, Japan, and South Korea. This paper argues that, despite the close proximity to China, the high-volume of travelers between the two countries, a more aged population, and a high urban density, Japan has been able to flatten its curve initially. There are possibilities of second or third waves of infection in Japan, but at least the gap between the first and possibly forthcoming second wave has given the health care system enough time to prepare itself to adequately respond. From the study, it is evident that Japan has adopted a few important policies at the government level, which are supported by strong data and evidence-based analysis. The science-based decision/policy making was at the core of the government response. The other important part was a combination of five other factors: culture, health care system, sanitation, food habit, and immune status. Although these factors are very much Japan-related, the governance actions can be replicated in other parts of the world to cope with the pandemic.

To cope with future pandemic risks, we need to have the following:

(1) Robust integrated health and emergency management policy, the basic healthcare system should be a core pillar of society. During the pandemic response, an integrated emergency response system is required, where decisions are made based on science and expert advice, and adaptive policy responses are ensured. Chan and Shaw (2020) provided several cases of incorporating public health in disaster risk reduction [46] and vice versa through the health emergency disaster risk management framework (WHO 2019) [47–49].
(2) A healthy lifestyle is key to promote a healthy immune system. An ecosystem-based lifestyle change is essential, as exemplified above in the case of Japan. Mukherjee et al. [50] argued for an ecosystem-based business continuity plan to recover from COVID-19.
(3) Use of new and emerging technologies: online classes, meetings, telework, etc. Extensive use of 5G and other information-related developments is essential [3]
(4) Being responsible and risk-aware citizens, employing a civic sense, and behavioral changes are core to any pandemic response [2,3].

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References

1. WHO. *COVID 10 Public Health Emergency of International Concern: Global Research and Innovation Forum*; WHO: Geneva, Switzerland, 2020; p. 7.
2. Hua, J.; Shaw, R. Corona Virus (COVID-19) "Infodemic" and Emerging Issues through a Data Lens: The Case of China. *Int. J. Environ. Res. Public Health* **2020**, *17*, 2309. [CrossRef] [PubMed]
3. Shaw, R.; Kim, Y.K.; Hua, J. Governance, technology and citizen behavior in pandemic: Lessons from COVID-19 in East Asia. *Prog. Disaster Sci.* **2020**. [CrossRef]
4. Nippon.com. Coronavirus Cases by Country. 2020. Available online: https://www.nippon.com/en/japan-data/h00673/coronavirus-cases-by-country.html (accessed on 17 April 2020).
5. MHLW. Current Situation and MHLW Response to COVID-19. *Ministry of Health, Labor, and Welfare (in Japanese).* 2020. Available online: https://www.mhlw.go.jp/stf/newpage_10904.html (accessed on 17 April 2020).
6. MHLW. About coronavirus disease 2019. 2020. Available online: https://www.mhlw.go.jp/stf/seisakunitsuite/bunya/newpage_00032.html (accessed on 15 April 2020).
7. PMO. Prime Minister Office of Government of Japan. 2020. Available online: http://japan.kantei.go.jp/ongoingtopics/_00013.html (accessed on 15 April 2020).
8. Wiki. 2020 Coronavirus Pandemic in Japan. 2020. Available online: https://en.wikipedia.org/wiki/2020_coronavirus_pandemic_in_Japan (accessed on 15 April 2020).
9. Rich, M.; Ueno, H. Japan's Virus Success has Puzzled the World. Is its Luck Running Out? The New York Times. 2020. Available online: https://www.nytimes.com/2020/03/26/world/asia/japan-coronavirus.html (accessed on 7 April 2020).
10. Mainichi Shimbun. State of Emergency for Tokyo and Six other Prefectures on April 7 To Ramp up Defenses against the Spread of the New Coronavirus. 2020. Available online: https://mainichi.jp/weekly/articles/20200417/wek/00m/040/002000c (accessed on 7 April 2020).
11. Mine, Y. "Immigration Restrictions" and "Isolation" Comparison of Japanese Governments and Japanese Responses against New Coronavirus. Yahoo Japan News. 2020. Available online: https://headlines.yahoo.co.jp/hl?a=20200224-00010003-wordleaf-pol&p=1 (accessed on 7 April 2020).
12. New Cases of Coronavirus Disease (COVID-19) Confirmed by day in Japan from January 14 to June 1 2020. Available online: https://www.statista.com/statistics/1105032/japan-new-confirmed-cases-of-coronavirus-by-day/ (accessed on 7 June 2020).
13. Miyoshi, K.; Murayama, H. Mobility changes in Tokyo, The Global Data Science Project for COVID-19. 2020. Available online: https://www.covid19analytics.org/post/social-distancing (accessed on 10 May 2020).

14. Takeda, T.; Kamagahara, Y.; Lu, X.; Kida, N.; Hara, T.; Ota, T. Study of the difference in the movement of experienced and inexperienced persons in Japanese bowing. In *Advances in Intelligent Systems and Computing*; Springer: Cham, Switzerland, 2017. [CrossRef]
15. ThePrint. Social Distancing is the Norm in Japan. *That's why COVID-19 Spread is Slow there. The Print.* 2020. Available online: https://theprint.in/health/social-distancing-is-the-norm-in-japan-thats-why-covid-19-spread-is-slow-there/384498/ (accessed on 7 April 2020).
16. Imada, T. Cultural Narratives of Individualism and Collectivism: A Content Analysis of Textbook Stories in the United States and Japan. *J. Cross-Cult. Psychol.* **2012**. [CrossRef]
17. Furuya, S. Reinterpretation of Japanese Collectivism: Based on "Self-Interested Cooperation." Global studies. *Musashino Univ. Acad. Inst. Repositry*. 2018. Available online: http://id.nii.ac.jp/1419/00000861/ (accessed on 7 April 2020).
18. Ishii, M.; Hamamoto, M.; Tsuruoka, H. JMA perspectives on the universal health insurance system in Japan. *Jpn. Med Assoc. J.* **2010**, *53*, 139–143.
19. Yano, H. Coronavirus: Why Japan tested so Few People. Retrieved 12 March 2020, from NIKKEI Asian Review. 2020. Available online: https://asia.nikkei.com/Spotlight/Coronavirus/Coronavirus-Why-Japan-tested-so-few-people (accessed on 7 April 2020).
20. Information for Public. Q & A on Coronavirus Disease 2019 (COVID-19). *Ministry of Health, Labor and Welfare.* 2020. Available online: https://www.mhlw.go.jp/stf/seisakunitsuite/bunya/kenkou_iryou/dengue_fever_qa_00014.html (accessed on 7 April 2020).
21. Ai, T.; Yang, Z.; Hou, H.; Zhan, C.; Chen, C.; Lv, W.; Xia, L. Correlation of Chest CT and RT-PCR Testing in Coronavirus Disease 2019 (COVID-19) in China: A Report of 1014 Cases. *Radiology* **2020**. [CrossRef] [PubMed]
22. UNICEF. Everything You need to Know about Washing your Hands to Protect against Coronavirus (COVID-19). Retrieved April 7, 2020, from UNICEF website. Available online: https://www.unicef.org/georgia/stories/everything-you-need-know-about-washing-your-hands-protect-against-coronavirus-covid-19 (accessed on 7 April 2020).
23. Asia Development Bank. Sanitation and Sustainable Development in Asia. 2016. Available online: https://www.adb.org/sites/default/files/publication/209511/sanitation-sustainable-dev-japan.pdf (accessed on 3 April 2020).
24. UNICEF. Handwashing with Soap, Critical in the Fight against Coronavirus, is 'out of reach' for Billions—UNICEF. 2020. Available online: https://www.unicef.org/eap/press-releases/handwashing-soap-critical-fight-against-coronavirus-out-reach-billions-unicef (accessed on 7 April 2020).
25. MHLW. The Results of the 1st "National Survey for New Corona Countermeasures" and Announcement of the 3rd "National Survey for New Corona Countermeasures." Ministry of Health, Labor, and Welfare (in Japanese). 2020. Available online: https://www.mhlw.go.jp/stf/newpage_10798.html (accessed on 7 April 2020).
26. Baseel, C. Gargling to Prevent Colds—Just a Japanese old Wives' Tale? JAPANTODAY. 2014. Available online: https://japantoday.com/category/features/health/gargling-to-prevent-colds-just-an-japanese-old-wives-tale (accessed on 7 April 2020).
27. Satomura, K.; Kitamura, T.; Kawamura, T.; Shimbo, T.; Watanabe, M.; Kamei, M.; Tamakoshi, A. Prevention of upper respiratory tract infections by gargling: A randomized trial. *Am. J. Prev. Med.* **2005**. [CrossRef] [PubMed]
28. Bell, V.; Ferrão, J.; Pimentel, L.; Pintado, M.; Fernandes, T. One Health, Fermented Foods, and Gut Microbiota. *Foods* **2018**, 195. [CrossRef] [PubMed]
29. Veld, E.V.T. 7 Japanese Superfoods to Boost your Immune System. 2020. Available online: https://japantoday.com/category/features/food/7-japanese-superfoods-to-boost-your-immune-system (accessed on 7 April 2020).
30. Déléris, P.; Nazih, H.; Bard, J.M. Seaweeds in Human Health. In *Seaweed in Health and Disease Prevention*; Academic Press: Cambridge, MA, USA, 2016. [CrossRef]
31. Wildish seaweed. Can Irish Seaweed help in the Fight against Viruses? 2020. Available online: https://www.wildirishseaweeds.com/can-irish-seaweed-help-in-the-fight-against-viruses/ (accessed on 7 April 2020).

32. Nania, R. How Chronic Conditions Complicate Coronavirus Infections. AARP. 2020. Available online: https://www.aarp.org/health/conditions-treatments/info-2020/chronic-conditions-coronavirus.html (accessed on 7 April 2020).
33. Knapton, S. Coronavirus has Mutated into more Aggressive Disease, say Scientists. The Telegragh. 2020. Available online: https://www.telegraph.co.uk/science/2020/03/04/coronavirus-has-mutated-aggressive-disease-say-scientists/ (accessed on 7 April 2020).
34. Kamikubo, Y.; Takahashi, A. Epidemiological Tools that Predict Partial Herd Immunity to SARS Coronavirus 2. *MedRxiv* **2020**. [CrossRef]
35. Nishijima, S.; Suda, W.; Oshima, K.; Kim, S.W.; Hirose, Y.; Morita, H.; Hattori, M. The gut microbiome of healthy Japanese and its microbial and functional uniqueness. *DNA Res.* **2016**. [CrossRef] [PubMed]
36. Kida, S. Image Diagnosis in Japan 2 -Comparison of CT and MRI Numbers and imaging Frequency with OECD Countries-. Imacel Academy. 2018. Available online: https://lp-tech.net/articles/8fix9 (accessed on 7 April 2020).
37. McCarthy, N. Where Europeans Wash Their Hands After Using The Toilet. Statista. 2020. Available online: https://www.statista.com/chart/4111/do-europeans-wash-their-hands-after-using-the-toilet/ (accessed on 7 April 2020).
38. Palahí, M.; Pantsar, M.; Costanza, M.; Kubiszewski, M.; Potočnik, J.; Stuchtey, M.; Bas, L. Investing in Nature to Transform the Post COVID-19 Economy: A 10-point Action Plan to create a circular bio-economy devoted to sustainable wellbeing. 2020. Available online: https://www.thesolutionsjournal.com/article/investing-nature-transform-post-covid-19-economy-10-point-action-plan-create-circular-bioeconomy-devoted-sustainable-wellbeing/ (accessed on 9 June 2020).
39. Hagihara, Y.; Hagihara, K. Chapter 2 Water Resources Conflict Management: Social Risk Management. In *Coping with Regional Vulnerability, New Frontiers in Regional Science: Asian Perspectives 4*; Hagihara, K., Asahi, C., Eds.; Springer: Tokyo, Japan, 2016; pp. 21–41.
40. Hagihara, Y. *Adaptive System Planning Methodology for Environmental Risk Management*; Kyoto University Press: Kyoto, Japan, 2008. (In Japanese)
41. AFP BB News. The Cause of the Corona Pandemic is "Disrespect of Animals" Said by Mr. Goodall, a primatologist.. 2020. Available online: https://www.afpbb.com/articles/-/3278221 (accessed on 12 April 2020).
42. Jacobo, J. Venice Canals are Clear enough to see Fish as Coronavirus Halts Tourism in the City. abc NEWS. 2020. Available online: https://abcnews.go.com/International/venice-canals-clear-fish-coronavirus-halts-tourism-city/story?id=69662690 (accessed on 17 April 2020).
43. Orjollet, S.; Christensen, S. VIDEO: Why Coronavirus could Help Save China's Endangered Species. CAPITAL NEWSPAPERS. 2020. Available online: https://capitalnewspapers.co.za/afp/938372/video-why-coronavirus-could-help-save-chinas-endangered-species (accessed on 17 April 2020).
44. Mavrodieva, A.; Shaw, R. Disaster and climate change issues in Japan's Society 5.0—A discussion. *Sustainability* **2020**, *12*, 1893. [CrossRef]
45. Shaw, R.; Chatterjee, R.; Dabral, A. *Integrating Biological Hazards (including Pandemic) into Disaster Risk Reduction (DRR) Planning, Annex Document*; UNDRR: Baltimore, MD, USA, 2020; p. 71.
46. Chan, E.; Shaw, R. Overview of health-EDRM and health issues in DRR: Practices and challenges. In *Public Health and Disasters*; Chan, E.Y.Y., Shaw, R., Eds.; Springer: Singapore, 2020; pp. 1–6.
47. WHO. *Health Emergency and Disaster Risk Management Framework*; WHO: Geneva, Switzerland, 2019.
48. DeWitt, A.; Djlante, R.; Shaw, R. Building holistic resilience: Tokyo's 2050 strategy. *Asia Pac. J.* **2020**, *18*, 1–5.
49. Djlante, R.; Shaw, R.; DeWit, A. Building resilience against biological hazards and pandemics: COVID-19 and its implications for the Sendai Framework. *Prog. Disaster Sci.* **2020**. [CrossRef]
50. Mukherjee, M.; Chatterjee, R.; Khanna, B.K.; Dhillon, P.P.S.; Kumar, A.; Bajwa, S.; Shaw, R. Ecosystem-centric business continuity planning (Eco-centric BCP)- a post COVID19 new normal. *Progress Disaster Sci.* **2020**. In press.

COVID-19 initial preparedness and response in Vietnam during the first six months of the pandemic and the lessons for Sendai framework implementation

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Abstract

Purpose – This paper aims to analyze the current responses applied in Vietnam to the Coronavirus disease (COVID-19) pandemic and link these measures to priority actions highlighted in the Sendai Framework for Disaster Risk Reduction (SFDRR). From there, strengths, limitations and recommendations on applying the SFDRR to build the pandemic resilience in the future are discussed.

Design/methodology/approach – The authors synthesize literature on response measures to the COVID-19 pandemic in Vietnam from January to June 2020 and compare to four priority actions of the SFDRR including understanding risk, strengthening governance, investing in risk reduction for resilience and enhancing preparedness for effective response and resilient recovery.

Findings – Vietnam has effectively controlled the pandemic with 401 infected cases and no death so far. Well preparation, timely policies' implementation, risk communication and comprehensive approaches are key strategies. These measures are same as the four priority actions in the SFDRR.

Originality/value – To the best of the authors' knowledge, this is the first study in Vietnam to link the COVID-19 response and the SFDRR, which can serve as an important example for other countries in responding to the pandemic. Some measures have surpassed SFDRR's guidance, especially preventive responses applied nationwide with strong political will and the community's commitment accompanied by sanctions. Cultural factors such as the habit of using masks to prevent air pollution have contributed to the good observance of wearing mask regulations during the pandemic. However, some areas that need more attention include specific solutions for vulnerable groups, limiting fake news and ensuring patient privacy.

Keywords Vietnam, Preparedness, Sendai Framework for Disaster Risk Reduction, Response, COVID-19, SFDRR

Paper type Research paper

1. Introduction

The COVID-19 pandemic caused by the Severe Acute Respiratory Syndrome (SARS)-CoV-2 virus is one of the greatest health, social, financial and political crises of the 21st century.

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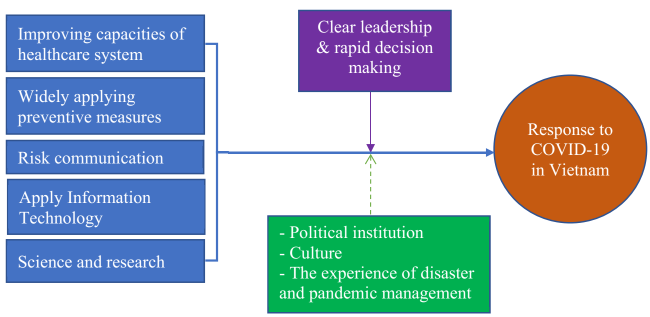
Since the first cases appeared in Wuhan, China in late 2019, seven months later, the COVID-19 has hit at least 188 out of 195 countries, leading to more than 15 million cases and over 600 thousand deaths (WHO, 2020). These numbers are continuing hourly increased for the next months and all countries are at very high risk. During the past decades, the world has experienced many pandemics such as SARS, MERS, Influenza A(H5N1) and H1N1. Many lessons and experiences have been achieved. However, for this COVID-19 pandemic, almost all parts of the world, even the wealthiest countries with an advantaged health-care system, have fallen into a severe crisis. Global Preparedness Monitoring Board (2019) concluded that the world still lacks preparation for the pandemic, and in fact, what have happened during the COVID-19 pandemic showed unreadiness in many countries. The world has witnessed many mistakes such as the ill-preparation for a pandemic of many countries, the overload of the health system and ineffective risk communication. The pandemic has led to social instability, fear, hoarding, panic-buying, misinformation and rumors, which can lead to inappropriate response of communities, increase racial discrimination and violent behaviors (Devakumar *et al.*, 2020; Dinis-Oliveira, 2020).

Pandemic responses were not merely medical solutions but required a more comprehensive and long-term strategy based on an inter-, trans- and multi-disciplinary approach (Chan and Murray, 2017). In other words, a strategic framework needs to be developed to improve the national and international response to epidemics, especially governance and decision-making in a health crisis (Zhang and Shaw, 2020). Therefore, applying a transnational response plan to a pandemic as well as a Potential Global Medical Emergency has been becoming ever more important. The World Conference on Disaster Risk Reduction in 2015 adopted The Sendai Framework (SFDRR) (2015–2030). This is the one of the most updated and comprehensive international accords on emergency response in technological, biological and environmental hazards (Aitsi-Selmi *et al.*, 2015). The SFDRR with an all-hazards approach with seven targets and four priorities of actions aims to strengthen international, national and local resilience to disasters and health emergencies including pandemics (Djalante *et al.*, 2020). Therefore, the idea of applying the Sendai Framework to build a comprehensive and long-term pandemic response plan is attracting the attention of international organizations and many public health researchers. Djalante *et al.* (2020), on its analysis on Sendai Framework, made recommendations on how current disaster resilience strategies can support to control COVID-19, including stronger science provision on disaster and health emergency risk; mobilize existing disaster risk governance structure to manage health emergencies; using existing disaster coordination mechanism in the regional and local levels to inform epidemic response plans; understanding economic effects and resilience capacity; preparing an early recovery plan; and strengthening the emergency preparedness and response of the community. In another COVID-19 research, Tashiro and Shaw (2020) pointed out six factors for Japan's low death rate, despite proximity to China, the high aged population and high urban density. These are government response, culture, health-care system, sanitation, food habits and immunity system. These conclusions were mostly consistent with the Sendai Framework's goal and priorities for actions (Zhang and Shaw, 2020). Up to the present, Vietnam was one of the successful countries in dealing with the COVID-19 pandemic. After more than six months from the first case (January 23), the total number of coronavirus infections update to July 22, 2020 in Vietnam was only 401 cases and no death has been recorded (Ministry of Health, 2020d). Meanwhile, up to 11.28% (22/195) and 38.97% (76/195) countries in the world had COVID-19 cases over 100,000 and 10,000, respectively (Worldometer, 2020). At the first stage, Vietnam was assessed as a high-risk country for spreading the epidemic because it is a densely populated country with over 97 million people (294 people/km^2), limited resources, a less advanced health-care system, sharing a long border and a high volume of trade with China – where the disease originated (The World Bank, 2020). Also, Vietnam is one of the top tourist destinations in Southeast Asia with over 15 million international visitors and 80 million domestic traveler trips each year (V. T. Dinh *et al.*, 2019). However, timely and appropriate responses have effectively prevented and controlled the pandemic. Vietnam currently moved to the post-pandemic recovery stage as no community transmission has been reported since mid-April 2020 (Ministry of Health, 2020d). The government eased some restrictions, restarting and stimulating the economy while maintaining principal preventive measures and preparing for the next potential epidemic waves because of the rapid spread of the virus worldwide (Ministry of Health, 2020d).

Response strategies of Vietnam were considered as one of the most cost-effective approaches (Heath and Jin, 2020). However, these strategies seem to be based on previous outbreak prevention experiences rather than scientific evidence because at that time there was a lack of evidence of the spread and severity of the COVID-19 pandemic. Therefore, some policies may not adequately consider disadvantaged groups and sensitive issues regarding personal information security (UNDP Vietnam, 2020). Governance in a pandemic is a big challenge; therefore, it is necessary to incorporate pandemic risks, biological and disaster hazards in national emergency response strategies. An analysis of Vietnam's responses based on SFDRR's priority actions and a discussion of the ways that the SFDRR can be implemented in risk management will contribute to strengthening the pandemic response capacity of Vietnam.

2. Key public health perspectives and decision measures

The Vietnamese Government has applied a comprehensive approach to respond to the COVID-19 pandemic. This paper divides response measures into five main categories, including improving the capacity of the health-care system, widely applying preventive measures, enhancing risk communication, applying information technology and investing in science and research. These measures were well-implemented, effective and synchronized across the country because of clear leadership and rapid decision-making at different levels. Moreover, the political institution, cultural characteristics and previous experiences in emerging infectious disease prevention and natural disaster adaptation were contributing factors for the success of COVID-19 prevention and control. Figure 1 (in the supplemental material) shows the key elements of these responses.



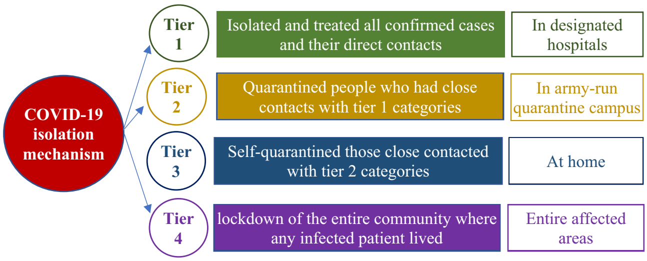
Source: Authors' own analysis

Figure 1.
Basic elements of COVID-19 response in Vietnam

Improving the response capacity of the health-care system including the curative and preventive sectors has become the first priority of the government. The Ministry of Health (MOH) has effectively directed and collaborated agencies, the hospital network and the provincial Centre for Disease Control and Prevention (CDC) in response to COVID-19. When a few COVID-19 cases were reported in Wuhan, China, the Vietnamese MOH has issued treatment guidelines and disseminated them to all health facilities across the country (Ministry of Health, 2020a). For example, MOH issued Decisions No. 181/QD-BYT, No. 237/QD-BYT, No. 343/QD-BYT, No. 344/QD-BYT and No. 345/QD-BYT from late January to early February about guidelines for COVID-19 monitoring and prevention, isolation mechanisms at households and facilities. Also, the MOH issued guidelines for COVID-19 prevention and treatment for vulnerable groups such as the elderly (Decision No. 1588/QD-BYT), pregnant women and infants (Decision No. 1271/QD-BYT). On January 30, 2020, the National Steering Committee under the leadership of the Vice Prime Minister Vu Duc Dam and 24 members of 12 related ministries were established (Decision No. 170/QD-TTg), along with 45 Rapid Response Teams in major hospitals across the country (Van Nguyen *et al.*, 2020). On February 1, the Vietnamese Prime Minister officially declared epidemic when only six cases were reported in three provinces (Decision No. 173/QD-TTg) and the national epidemic was declared 2 months later on April 1 when the infection reached 212 cases in 25 provinces (Decision No. 447/QD-TTg) (Tuan, 2020). The MOH and the national committee implemented a rapid assessment of the capacity and needs of health facilities in the treatment of COVID-19 patients and developed five different response scenarios in cases infected people exceeded 100, 1,000, 10,000, 30,000 or more (*Vietnam Finance Times*, 2020). The shortage of health-care workers, hospital beds and ventilators also were identified. Besides, Vietnamese scientists have produced three different test kits to diagnose COVID-19 that cost less than the US$25, gave a result within 90 min and met the WHO's standard (*Vietnam Insider*, 2020). The number of tests meets the domestic demand and exports to 20 other countries (VOA News, 2020). Vietnam also has increased the number of laboratories that can test COVID-19 from 03 laboratories in January to 112 in April 2020 (Ministry of Health, 2020c). Furthermore, temporary hospitals to quarantine and treat COVID-19 patients have been set up since mid-February 2020 to prepare for the worse scenarios of the epidemic (La *et al.*, 2020).

Vietnam has taken a series of *strictly public health prevention* to control the COVID-19. These measures have applied a week before WHO's declaration that the COVID-19 is an emergency of international public health concern and more than one month before recognized as a global pandemic (Le, 2020). At that time, these actions were above and beyond the recommendations of WHO, but epidemiologists agreed that they were "extreme but sensible". Important measures included large scale quarantine and isolate all suspected cases with a four-tier approach of identification and isolation (Figure 2 – in the supplemental material), visa suspension for all foreigners and restrictions on international travel. Isolating all cases of entry into Vietnam significantly reduced the risk of outbreaks because up to July 7th, 2020, 70.1% (249) of COVID-19 patients were passengers entering Vietnam (Ministry of Health, 2020b).

Risk communication and applying information technology have been effectively used in all prevention and control activities, including online consultations, online medical declarations, risk communication and online learning. All COVID-19 information, especially new cases (coded as the patient numbers), their epidemiological information and their 14-day-travel history, was broadcasted and updated daily by almost all channels. Furthermore, the government and the MOH daily sent text messages to all citizens' mobile phones to warn the risks of infection and to promote protective behaviors. National phone



Source: Adapted from Vietnamese Ministry of Health's website (Ministry of Health, 2020b)

Figure 2. Four-tier quarantine mechanism of COVID-19 response in Vietnam

waiting ringtones also changed to a voice message giving notice of the COVID-19 (La *et al.*, 2020). On 9 March, two free applications, "NCOVI" and the "Vietnam Health Declaration" were developed to declare the medical conditions of each individual including Vietnamese citizens and international visitors (Tuoi Tre News, 2020). The apps and the official website "http://ncov.moh.gov.vn" provided an update Vietnam's epidemic map, official information about new cases, policies and guidelines about the pandemic prevention (Thuy, 2020). After just over a week of introduction, these two apps have become the most downloaded apps on Vietnam's Apple Store and ranked third on Vietnam's Google Play (Khoa, 2020). The communication strategies to help combat the COVID-19 pandemic have been developed diversely, targeting many different groups and through different communication channels. For example, short, catchy slogans such as "Staying at home is patriotic", "Put on a face mask, wash hands often" and "the virus is your enemy" were regularly displayed on television, posters, government websites and social networks (Vietnam Times, 2020). Facebook users were encouraged to put these slogans alongside their profile pictures to show solidarity in the fight against the COVID-19. Also, many poems, paintings and songs have been composed to urge people to take preventive behaviors. The song "Ghen Covy – Washing hand song" has become a phenomenon on social networks with millions of views, shares and downloads. The song has been also translated into more than 20 languages, performed by many international artists and appeared in various favorite shows in other countries (The Economic Times, 2020).

Vietnamese Government has *invested in science and research* to identify effective respond solutions. Epidemiologists, sociologists, economists and scientists have worked hard to rapidly provide scientific evidence to policymakers. Vietnam is one of the first countries to produce COVID-19 tests with low cost and high accuracy. Besides, numerous studies concerning COVID-19 in Vietnam have been implemented since few infected cases reported (Giang *et al.*, 2020). These papers focused on clinical aspects, knowledge-attitude-practice of the community and health-care workers, risk perception and government's response (L. Dinh *et al.*, 2020; G. Huynh *et al.*, 2020; T. L. Huynh, 2020; La *et al.*, 2020).

2.1 Key legislative and decision measures

Regarding the epidemiological characteristics, by June 30, 2020, the COVID-19 pandemic in Vietnam has two phases: the first phase (from January 23 to February 26) included patients from Wuhan, China and infected cases due to close contact with these patients. The second phase (from March 16 to June 30) came with cases traveling from other countries, close contact cases and cases of transmission in the community of unknown source. However, to better analyze Vietnam's strategies, the pandemic response and recovery are divided into five periods: Stage 1 – before the first case was reported in Vietnam; Stage 2 – the first phase of the epidemic; Stage 3 – break time with no new cases were recorded; Stage 4 – the second phase of the epidemic; and Stage 5 – the recovery period. Key legislative and decision measures are described in Table 1 (in the supplemental material).

2.2 Factors contributing to the success

One of the factors that helps Vietnam prevent and control the COVID-19 pandemic well was its previous experiences in emerging infectious disease prevention and natural hazards

Time	Total cases	Key measures
Wave 1 (Pre- Jan 22)		
Jan-03	0	Conducting rapid risk assessment for COVID-19
		Developing different response scenarios
		Establish Steering committee
Jan-15	0	*Temperature screening for all passengers from Wuhan, isolating inspected cases*
Jan-16	0	Providing guidelines to early prevention COVID-19
Wave 2 (Jan 23 -Feb 26)		
Jan-23	2	Announcing the first two cases in Vietnam
Jan-25	2	*Cancelled all flights to and from Wuhan*
Jan-30	5	*Establishing a National Steering Committee* and *45 Rapid Response Teams*
Feb-01	6	*Declared a national epidemic in Vietnam*
		Cancel all flights between Vietnam and China
		Quarantine and voluntary isolation suspected people at the community
Feb-07	13	Issuing National guideline on COVID-19 Prevention and Treatment
Feb-08		*Closing schools*
Feb-12	16	*Lockdown 20 days in a large commune after 11 people infected*
		Set up temporary hospitals
Wave 3 (Feb 27 -Mar 5)		
Feb-27	16	All control measures were continuously maintained
		Maintaining strict travel restrictions
	16	Military-civilian drills response to COVID-19
Wave 4 (Mar 6- April 22)		
Mar-06	17	*Announcing the first case travelled from Western countries*
		Compulsory wearing masks in public places
		Develop low-cost tests, increase laboratories can test COVID-19
		Temporary visa suspension and entry to all foreigners
Mar-21	88	*Compulsory 14-day isolation at concentration facilities for all people entering Vietnam. Cancel all foreign flights*
		Prohibiting all entertainment activities
Mar-30	203	*Declared a nationwide pandemic*
		Setting up testing kiosks
Mar-30		*Enforced whole society distancing within 15 days*
Apr-14		Extended social distancing at high-risk areas
Apr-15	268	Restricting domestic travel
Wave 5 (Apr 23- June 30)		
Apr-23	268	Lifting COVID-19 restrictions
Apr-28	270	Declared successful in controlling COVID-19
May-4	271	Reopened school and businesses
June-30	355	Still maintain key preventive measures

Source: Authors' own analysis

Table 1. Timeline key legislative measures

response. Vietnam is a hot spot for natural disasters and the 6th country in the world most affected by climate change (Eckstein *et al.*, 2019). Lessons from responding to health emergencies and disasters helped Vietnam be more proactive in coping with the COVID-19 epidemic. For example, in order to deal with COVID-19, Vietnam has applied early the "Four on-spot" Motto including leadership on-the-spot, human resources on-the-spot, logistics on-the-spot and supplies on-the-spot (Xuan Tran *et al.*, 2020). This is a principle for natural hazard prevention in Vietnam highlighting the role of the local community and the local government to actively respond to a crisis (Linh and Hanh, 2020). In addition, the lessons and experience in preventing and controlling previous epidemics such as Zika, Influenza A (H1N1), H5N1, Diarrhoea, Measle and Dengue fever have contributed to respond better to COVID-19 (Ohara, 2004; Siembieda *et al.*, 2015). Especially, in 2003, Vietnam became the first country to succeed in containing the SARS epidemic (WHO, 2003).

Vietnam is a socialist republic country with a one-party system; therefore, it was easier to make decisions in a short time and can immediately implement interventions on a national scale. If it was in the context of multi-party politics, such as in Western countries, these strict measures may not be applied in that timely manner because of disagreements about individual privacy. Habits and cultural norms also contribute to the success of control measures. For example, Vietnamese people especially women often wear face masks to protect sun exposure and air pollution; therefore, the regulation of using masks to prevent COVID-19 was well observed. Furthermore, village culture in which people in the community care and know each other has supported to contact tracing of potentially infected cases. People notified their neighbors and local authorities if there were any suspected cases or anyone has just come back from abroad without mandatory isolation.

3. Implications to Sendai framework

Timely responses of the Vietnamese Government to control the COVID-19 have achieved positive output indicators, and these also were the targets highlighted in the SFDRR, including reduce mortality, morbidity, affected people, minimize economic loss, as well as safety for the health system and health workers. The SFDRR pointed out that compliance should be encouraged through "mechanisms and incentives" (Raju and da Costa, 2018). However, in the context of the complicated and rapidly spreading the COVID-19 epidemic, the promotion of preventive behaviors appears to be less likely to ensure compliance than the application of powerful legal instruments combined with strict sanctions. For a more understanding of the advantages and limitations of Vietnam's responses in the COVID-19 pandemic, the following section reviews Vietnam's responses according to four action priorities outlined for local and national level in the SFDRR in terms of the key strengths and limitations.

3.1 Priority 1: understanding the risk

As mention above, Vietnam has implemented many timely important actions to understand the risk including risk and health capacity assessment, developing different response scenarios, and mapping high-risk provinces. At a very early stage, the MOH assessed the epidemiology characteristics of each patient, the 14-day travel history, making a list of people who had close contact with the patients and published information on media. Also, information technology was effectively used to inform the risk of infection, disease symptoms, prevention measures and high-risk areas. This information was shared frequently, publicly, transparently and easily accessible. From early January to April 4, there were 14,952 news items about the COVID-19 in the media channels such as newspapers, social networks and messages (La *et al.*, 2020).

Some limitations in Vietnam's responses compared to the priority action one in the SFDRR should need to be improved. There was a lack of vulnerability assessment of the elders, disabilities, homeless people and foreign tourists - who are high-risk and most affected by COVID-19. Also, there was no evaluation on vulnerability and adaptive capacity for other sectors in addition to health such as education, tourism, trade and services in the pandemic, as well as a lack of risk assessment related to environmental issues. In addition, some rumors and fake news related to COVID-19 widely spread on social networks have caused panic for the community. In the early stages of the epidemic, some personal information of COVID-19 patients was leaked on social networks, causing negative reactions from the community, affecting the patients' personal lives and reputation.

3.2 Priority 2: strengthening governance to manage risk

Clear leadership and effective governance were the keys to Vietnam's success in the COVID-19 control. Strong governance and a high degree of commitment from the Prime Minister - the highest political level - has promoted the participation of all sectors from central to local levels. The responsibilities and the coordination among the ministries, government agencies, organizations and local governments in the COVID-19 prevention and control were clearly assigned at the beginning of the epidemic. More importantly, the government issued a set of decisive intervention measures such as early border control, social distancing, wearing face masks, contact tracing all suspected cases and mass COVID-19 testing. These regulations were accompanied by economic sanctions to ensure high levels of compliance with communities. For example, the following acts will be punished: sharing fake news about the pandemic on social networks (fine of from 5,000,000 VND to 10,000,000 VND), not wearing a mask in public (fine of 100,000–300,000 VND), failure to make a medical report or make insufficient declaration leading serious consequences for the community (fine of 50,000,000-200,000,000 VND or imprisonment from 1 to 5 years) (Ministry of Health, 2020e). This penalty is relatively high compared to the average daily income per capita (VND 140,000 in 2019) (Doan, 2020). Also, community initiatives in COVID-19 prevention were promoted, such as sewing handmade face masks, making hand sanitizers, composing songs and slogans to raise the community's awareness. The government also established online forums and hotlines to increase coordination of stakeholders at national and local levels and promote public scrutiny in the detection and reporting of suspected cases.

There were, however, some limitations, which included: towing to the urgent time, public consultation has not been conducted in the process of developing laws and regulations related to COVID-19 prevention and control. In addition, the empowerment of local governments was emphasized in the SFDRR to enhance governance; nevertheless, in the complex context of an epidemic, this empowerment may need to be reconsidered as this may lead to inconsistencies in response measures. Furthermore, there was a lack of policies related to settling accommodation, relief for homeless people and tourists during the period of national entire lockdown.

3.3 Priority 3: investing in risk reduction for resilience

Core strengths in Priority 3 were integrating disaster and outbreak risk management into the health system, especially CDC network in 63 provinces across the countries. This network has been consolidated and worked effectively in previous outbreaks. Besides, the government allocated the necessary resources for the health-care system in the outbreak such as free treatment for all COVID-19 patients, investing funds in aggressive COVID-19 testing and contact tracing all potential infected cases. Vietnam experienced the first six months of the pandemic with no fatalities. This was because of the strict application of preventive and risk reduction measures. Controlling and keeping case numbers low has helped severe cases received full attention and were treated with the best doctors and advantaged equipment. In the cases that risk reduction is not implemented well, the number of people infected and fatal may significantly increase. In addition, scientific research in the field of treatment and prevention of COVID-19, as well as minimize epidemic-related risks has been enhanced and supported. The government also effectively applied information technology in disaster control and prevention. This is the first time that schools and businesses applied to online classrooms and online meetings. These online courses and the E-commerce industry in Vietnam will have great opportunities to develop after the pandemic.

There are two key limitations related to Priority 3 that need to be considered in the future. First, the current outbreak risk management plans and policies did not fully address the needs of vulnerable and disadvantaged groups such as the homeless, street vendors and foreign tourists. They were not supported in finding settlements when the whole country applies lockdown within 15 days. Second, there was a lack of promoting and integrating outbreak risk management approaches in many fields, especially the tourism industry – one of the sectors most affected by the pandemic.

3.4 Priority 4: enhancing preparedness for effective response and resilient recovery

Strengths in applying the SFDRR's Priority 4 were good preparedness for effective response through learning previous experiences, update new information and recommendations about the COVID-19 pandemic. Vietnam has regular disaster preparedness, response and recovery exercises every year. In the COVID-19 pandemic, an army simulation exercise in response to the epidemic was implemented on March 4, 2020 when the number of COVID-19 cases were only 16. In addition, in late April, Vietnam has implemented a set of measures to recover after the pandemic, especially social stability and economic resilience while still maintain principal preventive measures. The Government has issued financial assistance packages for employees and businesses affected by the COVID-19 pandemic to increase resilience.

Compared to Priority 4 of the Sendai Framework, some key limitations should be paid more attention. The first, empowering for disadvantaged groups was highlighted in the SFDRR; however, Vietnam's policies related to COVID-19 have not yet prioritized these groups. Besides, the government also should focus on psychological resilience after the pandemic for affected people such as COVID-19 patients, their family members and people who lost their jobs. For example, during the 2014 Ebola outbreak in West Africa, the number of people who died because of social service interruption and economic breakdown was higher than from the virus infection (United Nations, 2020). Also, risk assessment and resilient ability analysis of other sectors such as education, tourism and the environment should be implemented soon to effectively support the recovery. Regarding multi-hazards prevention, the government should develop a comprehensive strategy and coping scenarios to deal with multi-hazards such as natural disasters and a pandemic occurring at the same time. Another essential lesson is that current response measures of Vietnam were mainly based on experiences due to the lack of scientific evidence at the time of decision-making. Therefore, it is necessary to have research on the cost-effectiveness and multi-impacts of preventive measures such as school closing and wearing masks in public places, as well as more studies about the quality of life, mental health, human rights and environmental impacts during and after the pandemic.

4. Conclusions

Although the Sendai Framework has not been mentioned in directive documents by the Vietnamese Government related to the COVID-19 pandemic control and prevention, the current analysis pointed out that the response mechanism has a strong link to the SFDRR in terms of its four different priorities. The key success factors for the pandemic response in Vietnam included well preparation, timely policies' implementation, risk communication and comprehensive approaches. In general, these measures were in line with priorities for action in the SFDRR. However, it is necessary to develop a comprehensive plan to respond to multi-hazards including technological, biological and environmental disasters based on the SFDRR's action priorities and the country's political, economic, health and cultural characteristics.

Currently, there is very little early and rapid response from international institutes and organizations related to disaster risk reduction, despite the Sendai Framework's call for enhancing resilience from natural and biological hazards. Effective and relevant risk management of biological hazards changes with the advancement of science, clinical medicine and public health practices and policy. The latest technical guidelines and research findings to support planning may be found in WHO's Health-Emergency Disaster Risk Management: Health-EDRM (WHO, 2019). The COVID-19 pandemic will have a lasting impact on all aspects of development planning in the years to come. The pandemic brought into light the need for effective risk management to safeguard development and the implementation of the International Health Regulations, The Sustainable Development Goals (SDGs), the Sendai Framework, Paris Agreement and New Urban Agenda, as well as other frameworks. Future detailed analysis is required to link the COVID-19 impacts on Sendai and SDGs at the global, regional and national levels.

References

Aitsi-Selmi, A., Egawa, S., Sasaki, H., Wannous, C. and Murray, V. (2015), "The Sendai framework for disaster risk reduction: renewing the global commitment to people's resilience, health, and well-being", *International Journal of Disaster Risk Science*, Vol. 6 No. 2, pp. 164-176.

Chan, E.Y. and Murray, V. (2017), "What are the health research needs for the Sendai framework?", *The Lancet*, Vol. 390 No. 10106, pp. e35-e36.

Devakumar, D., Shannon, G., Bhopal, S.S. and Abubakar, I. (2020), "Racism and discrimination in COVID-19 responses", *The Lancet (Lancet)*, Vol. 395 No. 10231, pp. 1194-1194, doi: 10.1016/S0140-6736(20)30792-3.

Dinh, V.T., De Kleine Feige, A.I., Pham, D.M., Eckardt, S., Vashakmadze, E.T., Kojucharov, N.D. and Mtonya, B.G. (2019), "Taking stock: recent economic developments of Vietnam – special focus: Vietnam's tourism developments-stepping back from the tipping point-Vietnam's tourism trends, challenges and policy priorities", Retrieved from.

Dinh, L., Dinh, P., Nguyen, P.D., Nguyen, D.H. and Hoang, T. (2020), "Vietnam's response to COVID-19: prompt and proactive actions", *Journal of Travel Medicine*, Vol. 27 No. 3, p. taaa047.

Dinis-Oliveira, R.J. (2020), "COVID-19 research: pandemic versus 'paperdemic', integrity, values and risks of the 'speed science'", *Forensic Sciences Research*, Vol. 5 No. 2, pp. 1-14.

Djalante, R., Shaw, R. and DeWit, A. (2020), "Building resilience against biological hazards and pandemics: COVID-19 and its implications for the Sendai framework", Progress in Disaster Science, 100080.

Doan, E.Z. (2020), "Average monthly income per capita in Vietnam 2010-2019", available at: www.statista.com/statistics/1021888/vietnam-average-monthly-income-per-capita/#:~:text=In%202019%2C%20the%20average%20monthly,was%20about%209.32%20million%20VND

Eckstein, D., Künzel, V., Schäfer, L. and Winges, M. (2019), "Global climate risk index 2020", available at: www.germanwatch.org/sites/germanwatch.org/files/20-2-01e%20Global%20Climate%20Risk%20Index%202020_16.pdf

Giang, H.T.N., Shah, J., Hung, T.H., Reda, A., Truong, L.N. and Huy, N.T. (2020), "The first Vietnamese case of COVID-19 acquired from China", *The Lancet. Infectious Diseases*, Vol. 20 No. 4, pp. 408-409.

Global Preparedness Monitoring Board (2019), "A world at risk: annual report on global preparedness for health emergencies", available at: https://apps.who.int/gpmb/assets/annual_report/GPMB_annualreport_2019.pdf

Heath, R. and Jin, B. (2020), "Ranking the global impact of the coronavirus pandemic, country by country", available at: www.politico.com/interactives/2020/ranking-countries-coronavirus-impact/?fbclid=IwAR2PTVpquAYucgtS1BtXvYIoRxpwg6FLnOdgFP9HOmwTdZLTGZWCH2DhjiQ

Huynh, T.L. (2020), "The COVID-19 risk perception: a survey on socioeconomics and media attention", *Econ. Bull*, Vol. 40 No. 1, pp. 758-764.

Huynh, G., Nguyen, T.N.H., Vo, K.N. and Pham, L.A. (2020), "Knowledge and attitude toward COVID-19 among healthcare workers at district 2 hospital, Ho Chi Minh city", *Asian Pacific Journal of Tropical Medicine*, Vol. 13 No. 6, p. 260.

Khoa, D. (2020), "Health declaration app NCOVI surpasses Facebook as most downloaded in Vietnam", available at: https://e.vnexpress.net/news/news/health-declaration-app-ncovi-surpasses-facebook-as-most-downloaded-in-vietnam-4069215.html

La, V.P., Pham, T.H., Ho, M.T., Nguyen, M.H., P Nguyen, K.L., Vuong, T.T., Tran, T., Khuc, Q., Ho, M.T. and Vuong, Q.H. (2020), "Policy response, social media and science journalism for the sustainability of the public health system amid the COVID-19 outbreak", *Sustainability*, Vol. 12 No. 7, p. 2931.

Le, S.M. (2020), "Containing the coronavirus (COVID-19): lessons from Vietnam", available at: https://blogs.worldbank.org/health/containing-coronavirus-covid-19-lessons-vietnam

Linh, T.N.Q. and Hanh, T.T.T. (2020), "Public health and disaster risk reduction: experiences from Vietnam", *Public Health and Disasters*, Springer, pp. 265-280.

Ministry of Health (2020a), "Decision no.125/QD-BYT on guideline for diagnosis and treatment for novel coronavirus infection".

Ministry of Health (2020b), "Inforgraphics, charts and maps of COVID-19: the world and Vietnam", available at: https://ncov.vncdc.gov.vn/pages/viet-nam-1.html

Ministry of Health (2020c), "Successfully producing new biological products, Vietnam has used two methods of testing COVID-19", available at: https://moh.gov.vn/tin-noi-bat/-/asset_publisher/3Yst7YhbkA5j/content/san-xuat-thanh-cong-sinh-pham-moi-viet-nam-lam-chu-2-phuong-phap-xet-nghiem-covid-19

Ministry of Health (2020d), "Trang tin về dịch bệnh viêm đường hô hấp cấp COVID-19", available at: https://ncov.moh.gov.vn/

Ministry of Health (2020e), "08 vi phạm liên quan đến Covid-19 và mức phạt (translate: fines for 08 common non-compliance of COVID-19 rules)", available at: https://ehealth.gov.vn/Index.aspx?action=News&newsId=52256

Ohara, H. (2004), "Experience and review of SARS control in Vietnam and China", *Tropical Medicine and Health*, Vol. 32 No. 3, pp. 235-240.

Raju, E., da Costa, K. (2018), "Governance in the Sendai: a way ahead?", *Disaster Prevention and Management: An International Journal*, Institutionen för globala, s., Göteborgs, u., Gothenburg, U., Samhällsvetenskapliga, f., . . . Faculty of Social, S., Vol. 27 No. 3, pp. 278-291, doi: 10.1108/DPM-08-2017-0190.

Shaw, R., Kim, Y-K. and Hua, J. (2020), "Governance, technology and citizen behavior in pandemic: lessons from COVID-19 in East Asia", Progress in Disaster Science, 100090.

Siembieda, J., Huong, N.T., Hung, P., Bandyopahyay, S. and Olowokure, B. (2015), "Prioritization of zoonotic diseases of public health significance in Vietnam", *The Journal of Infection in Developing Countries*, Vol. 9 No. 12, pp. 1315-1322.

Tashiro, A. and Shaw, R. (2020), "COVID-19 pandemic response in Japan: what is behind the initial flattening of the curve?", *Sustainability*, Vol. 12 No. 13, p. 5250.

The Economic Times (2020), "Take a break from coronavirus panic: Vietnam's handwash dance challenge goes viral", available at: https://economictimes.indiatimes.com/magazines/panache/take-a-break-from-coronavirus-panic-vietnams-handwash-dance-challenge-goes-viral/articleshow/74457876.cms

The World Bank (2020), "Vietnam overview", available at: www.worldbank.org/en/country/vietnam/overview

Thuy, B. (2020), "Bộ Y tế ra mắt hai kênh thông tin về dịch bệnh do nCoV. [Ministry of Health introduces two information channels about the nCoV outbreak]", available at: http://dangcongsan.vn/thoi-su/bo-y-te-ra-mat-hai-kenh-thong-tin-ve-dich-benh-do-ncov-548197.html

Tuan, V. (2020), "Vietnam PM declares Covid-19 a national epidemic", available at: https://e.vnexpress.net/news/news/vietnam-pm-declares-covid-19-a-national-epidemic-4078006.html

Tuoi Tre News (2020), "Vietnam launches apps for health declaration", available at: https://tuoitrenews.vn/news/society/20200310/vietnam-launches-apps-for-health-declaration/53404.html

UNDP Vietnam (2020), "Rapid assessment of the socio-economic impact of COVID-19 on persons with disabilities in Vietnam", available at: www.vn.undp.org/content/vietnam/en/home/library/democratic_governance/ImpactPwDs.html

United Nations (2020), "A UN framework for the immediate socio-economic response to COVID-19", available at: https://unsdg.un.org/sites/default/files/2020-04/UN-framework-for-the-immediate-socio-economic-response-to-COVID-19.pdf

Van Nguyen, H., Van Hoang, M., Dao, A.T.M., Nguyen, H.L., Van Nguyen, T., Nguyen, P.T., Khuong, L.Q., Le, P.M. and Gilmour, S. (2020), "An adaptive model of health system organization and responses helped Vietnam to successfully halt the Covid-19 pandemic: what lessons can be learned from a resource-constrained country", The International journal of health planning and management.

Vietnam Finance Times (2020), "Lên kịch bản ứng phó với hàng nghìn ca nhiễm virus covid-19. [scenarios in response to thousands of COVID-19 cases]", available at: http://thoibaotaichinhvietnam.vn/pages/thoi-su/2020-03-23/len-kich-ban-ung-pho-voi-hang-nghin-ca-nhiem-virus-covid-19-84211.aspx

Vietnam Insider (2020), "WHO approved COVID-19 test kits from Vietnam", available at: https://vietnaminsider.vn/who-approved-covid-19-test-kits-from-vietnam/

Vietnam Times (2020), "Vietnam's anti-COVID-19 'weapon': [art 3, mighty slogans", available at: https://vietnamtimes.org.vn/vietnams-anti-covid-19-weapon-part-3-mighty-slogans-21793.html

VOA News (2020), "Vietnam poised to export COVID-19 test kits", available at: www.voanews.com/covid-19-pandemic/vietnam-poised-export-covid-19-test-kits

WHO (2003), "Severe acute respiratory syndrome (SARS) – multi-country outbreak – update 41", available at: www.who.int/csr/don/2003_04_28/en/

WHO (2019), "Health emergency and disaster risk management framework", available at: www.who.int/hac/techguidance/preparedness/health-emergency-and-disaster-risk-management-framework-eng.pdf?ua=1

WHO (2020), "Coronavirus disease (COVID-2019) situation reports", available at: www.who.int/emergencies/diseases/novel-coronavirus-2019/situation-reports

Worldometer (2020), "COVID-19 coronavirus pandemic – last updated June 18, 2020", available at: www.worldometers.info/coronavirus/?fbclid=IwAR17f1spN24eDVKCLt9_BGpvsvl96_HPIkDLVBhrMp7Hu5qjSbCNo7fCIa0

Xuan Tran, B., Nguyen, H.T., Pham, H.Q., Le, H.T., Vu, G.T., Latkin, C.A., Ho, C.S. and Ho, R.C. (2020), "Capacity of local authority and community on epidemic response in Vietnam: implication for COVID-19 preparedness", *Safety Science*, Vol. 130, p. 104867, doi: 10.1016/j.ssci.2020.104867.

Zhang, H. and Shaw, R. (2020), "Identifying research trends and gaps in the context of covid-19", *International Journal of Environmental Research and Public Health*, Vol. 17 No. 10, p. 3370.

Further reading

Hua, J. and Shaw, R. (2020), "Corona virus (Covid-19)"infodemic" and emerging issues through a data lens: the case of China", *International Journal of Environmental Research and Public Health*, Vol. 17 No. 7, p. 2309.

Sajadi, M.M., Habibzadeh, P., Vintzileos, A., Shokouhi, S., Miralles-Wilhelm, F. and Amoroso, A. (2020), "Temperature and latitude analysis to predict potential spread and seasonality for COVID-19", Available at SSRN 3550308.

Tosepu, R., Gunawan, J., Effendy, D.S., Lestari, H., Bahar, H. and Asfian, P. (2020), "Correlation between weather and Covid-19 pandemic in Jakarta, Indonesia", Science of The Total Environment, 138436.

Wang, J. Tang, K. Feng, K. and Lv, W. (2020), "High temperature and high humidity reduce the transmission of COVID-19", Available at SSRN 3551767.

World Bank Group (2019), "Climate change knowledge portal: country Vietnam", available at: https://climateknowledgeportal.worldbank.org/country/vietnam/vulnerability

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Article

COVID-19 Lockdown, Food Systems and Urban–Rural Partnership: Case of Nagpur, India

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Abstract: The globally fast-spreading novel coronavirus disease (COVID-19) is now testing the abilities of all countries to manage its widespread implications on public health. To effectively contain its impacts, a nation-wide temporary lockdown was enforced in India. The resultant panic buying and stockpiling incidents together with spread of misinformation created a sense of food insecurity at local level. This paper discusses a specific case of Nagpur from the worst affected Maharashtra state of India, wherein the urban–rural food supply chains were reportedly disrupted. Based on formal interviews with local government officials, a month-long timeline of COVID-19 outbreak in Nagpur was studied along with the consequent government initiatives for maintaining public health and food supply. While the city residents were confined to their homes, this study then assessed their perceived food security at household level, along with their "Immediate Concerns" and "Key Information Sources". Through online surveys at two different time intervals, the concerns of "Food and Grocery" were found to be rising, and "Government Apps and Websites" were identified as the most reliable source of information. Based on the research findings, the authors further suggest specific policy recommendations for addressing the immediate and long-term concerns related to food systems in Nagpur.

Keywords: COVID-19; lockdown; food systems; food security; supply chain; urban–rural

1. Introduction

Coronavirus disease 2019 (COVID-19) is a respiratory illness caused by the novel coronavirus, officially referred to as Severe Acute Respiratory Syndrome coronavirus (SARS-COV-2), which was first detected in China, in December 2019. There is currently no evidence if food is a likely source or route of transmission of this virus, but it has been reported to originate from the world-famous Huanan seafood market in Wuhan city. Four months later on 11 March 2020, the World Health Organization (WHO) declared the coronavirus outbreak a pandemic, after it spread over several countries affecting a large number of people [1]. As per the global tally kept by the Johns Hopkins University [2], until 1 August 2020, the virus has already killed 675,213 people worldwide and more than 17.40 million cases have been confirmed in 188 out of 195 countries. The resultant panic situation due to COVID-19 outbreak is also being associated with the term "Infodemic", as huge amount of information and misinformation is flowing through different channels, including social media (also discussed by Hua and Shaw [3]). In the wake of COVID-19 global health emergency, terms such as "Quarantine", "Social distancing" and "Lockdown" have today become the buzz words. A lockdown in this context mainly refers to the restrictions being imposed by the governments on movement of people and goods to prevent the spread of infections.

Although COVID-19 is reported to be not as deadly in comparison to past pandemics such as Ebola virus disease, SARS and Middle East Respiratory Syndrome (MERS) [4], its high transmissibility and rapid speed of spread have become a matter of serious concern for governments around the world. Djalante et al. [5] and Shaw et al. [6] discussed several international response measures, which are implemented to break the chain of virus transmission such as reduction in transportation (through all ground, ocean and air means), tightened border controls, travel bans, lockdowns, advanced surveillance, etc. While the pandemic is still unfolding, global agencies including WHO, the World Bank, the International Monetary Fund (IMF), the Food and Agriculture Organization of the United Nations (FAO) and the World Trade Organization (WTO) have projected its drastic impacts on global economy and food systems, unless fast measures are taken to contain the spread of infections.

Even before the outbreak of COVID-19, the global food systems were already at a critical juncture, as also discussed in the 2020 Global Food Policy Report [7]. As of 2018, more than 820 million people worldwide did not have secure access to food [8] (p. 6). Other widespread concerns of climate change, natural disasters, high population growth, poverty, malnourishment, changing consumption patterns, obesity, etc. have also been posing serious challenges for sustainable development, particularly in fast growing cities of Asia [9,10]. The sudden emergence of COVID-19 pandemic has currently overshadowed or rather aggravated the already existing concerns of food insecurity. According to a recent projection by the United Nations World Food Programme [11], COVID-19 may aggravate the risks of acute food insecurity for an additional 130 million people by the end of 2020.

Thus far, there have not been any major signs of global food shortages [1]. However, demand-side contractions have recently been witnessed due to the largescale closure of restaurants and other commercial food services [12]. As most countries are now under strict lockdowns or in similar situations, Petetin [13] uncovered that the majority of the food consumption is presently concentrated at the household level. Further, food prices are also reported to be increasing in cities around the world, as food supply from rural areas is disrupted due to the mobility restrictions [14] (p. 6). Cities have traditionally been dependent on areas outside their physical boundaries (mostly surrounding rural and peri-urban areas) to meet their food demands [15–18], but the sudden transport restrictions and shortage of manpower have presently disrupted the urban–rural food supply chains (from harvesting crops to food distribution) worldwide. While the jobs and livelihoods of food supply chain actors are at significant risk, the government mandated lockdowns are also found to be influencing the consumer behavior towards food along with their food priorities and lifestyles [19].

In a bid to contain the impacts of COVID-19 at an early stage, the Government of India (GoI) enforced a temporary nation-wide lockdown (the world's largest) from 24 March 2020, by confining more than 1.3 billion people to their homes [20]. Despite the fragile economy, the country's timely decision was highly appreciated by global agencies including WHO and IMF, mainly in consideration to their huge population and limited healthcare capacities [21]. Although comprehensive protection measures were put in place at various administrative levels [22], GoI also announced a huge stimulus package of 20 lakh crore Indian Rupees 'INR' (around 265 billion United States Dollars 'USD') to alleviate the economic impacts of COVID-19 [23]. Nevertheless, the negative implications of enforced lockdown in India have surfaced in form of a serious economic slowdown, panic-stricken migrant crisis, panic buying, etc. [24,25]. With around 195 million undernourished people, India already shares a quarter of the global hunger burden [26] and also performs poorly on indicators of child wasting, stunting and mortality, as per the Global Hunger Index 2016 [27]. In the lockdown phase, the situation is therefore particularly critical in Indian cities, where majority of fresh food supply is dominated by the unorganized retail market [28,29].

The wide-ranging implications of COVID-19 on local food systems are yet to be understood clearly, as very few evidence-based studies have emerged thus far. In the context of India, the media reports have however covered several issues. Mishra and Rampal [30] underlined that there is still a lack of rigorous academic studies that examine the impacts of COVID-19 on food insecurity. With an aim to bridge this gap, this paper discusses a specific case of Nagpur from the worst affected Indian state of

Maharashtra. As of 1 August 2020, the state of Maharashtra has reported more than 420,000 confirmed cases out of the total 1.64 million cases reported in India [31]. To control the spread of coronavirus infections in Nagpur in parallel to maintaining the local food systems, a range of government initiatives has been taken by the local authorities. At the same time, the incidents of panic-buying, spread of misinformation, etc. have raised food security related concerns among the city residents, as they stayed confined to their homes under the enforced lockdown. In regards to that, the three key objectives of this study were: (1) to firmly understand the chronology of COVID-19 outbreak in Nagpur and its implications on local food systems; (2) to understand the perceived food security of Nagpur city residents at household level during the lockdown phase and assess their perception regarding their "Immediate Concerns" and "Key Information Sources"; and (3) to suggest feasible recommendations for addressing the immediate and long-term concerns related to food systems in Nagpur. The food security assessment at household level is mainly intended to assess the effectiveness of local government initiatives in providing a secure food environment, as the city residents stayed confined to their homes under the enforced COVID-19 lockdown.

While the food supply chains are widely disrupted due to the enforced mobility restrictions, the urban areas have adversely been affected due to their predominant dependence on rural areas for meeting their fresh food demands. In that context, the study also aimed to highlight the importance of urban–rural partnerships for strengthening local food systems.

The paper is divided into six sections, including the Introduction (Section 1). Section 2 provides an overview of the most prominent advances in scientific literature related to food systems and COVID-19, which sets a broad context for the conducted research. Section 3 provides a brief introduction to the case study area of Nagpur, before explaining the adopted research methodology. The study results and analysis are presented in Section 4. Section 5 provides specific policy recommendations to address the immediate concerns identified through the study and sustain the local food systems in long-term. The key conclusions and limitations of the present research have been summarized in the last Section 6.

2. Theoretical Background

2.1. Implications of COVID-19 Lockdowns on Food Systems

Food systems are basically defined as the sum of actors (farmers, traders, consumers, etc.) and their interactions along the various stages of food value chain such as production, storage, processing, transport, distribution, etc. [7]. As the COVID-19 pandemic continues to be a major concern for the government agencies, only a handful of studies have so far been conducted to assess its impacts on local food systems and related actors. Bene [32] synthesized the wide-ranging adverse effects of COVID-19 on various actors involved in food systems, ranging from food producers to consumers. The study stressed that the COVID-19 impacts on food security are further worsened by the government mandated lockdowns and business closures, as they consequently lead to loss of income and purchasing power. These restrictions also pose detrimental effects on the food supply, as they not only cause labor shortage but also hinder the flow of agricultural goods and services. On the demand side, it leads to panic buying amongst the consumers and stockpiling. Further, based on a preliminary analysis of 31 European countries, Akter [33] produced reliable empirical evidence that reveals the increase in overall food prices due to stay-at-home restrictions. Galanakis [34] also discussed the food systems in the coronavirus era and raised an alert for global food security as billions of people are currently living under temporary lockdown or in similar situation.

2.2. Emerging Food Security Challenges and Assessment Methods

Food security is a multidimensional concept that conventionally stresses on food availability and accessibility at individual level, along with food quality and cultural preferences. As per the definition established by World Food Summit 1996 [35], "food security exists when all people, at all times, have physical and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life". In the present context, COVID-19 is directly undermining the food security through disrupted supply chains, and it is also causing indirect impacts due to lockdowns in terms of reduced household incomes, restricted physical access to food, etc. [36]. Niles et al. [37] further stressed that the ongoing COVID-19 pandemic affects all the four dimensions of food security, defined by the United Nations [38], namely availability, accessibility, utilization and stability. The changing consumer behavior linked to the panic buying and stockpiling incidents are already affecting the food availability in the short term, but in the long term other challenges in terms of food import–export, etc. may unfold. The relative increase in food prices due to COVID-19 lockdowns, the shortage of preferred products, etc. are also impacting the food accessibility in the recent times. For poor people specifically, the increased food costs and closure of informal food markets may impact their food utilization in terms of reduced diet quality and nutrition intake. Lastly, the stability of food supply is also threatened by COVID-19 due to varied reasons, as already discussed [36,37].

The 2008 global food crisis had earlier mainstreamed the importance of food security in the global policy agenda [39]. Since then, numerous efforts have been made to establish measures for understanding this multifaceted concept. A variety of research frameworks and indicator sets have also been developed for the assessment of food security at different levels such as individual, household, community, national, regional and global [40]. The wide-ranging indicator sets have focused on variety of dimensions (availability, access, utilization, consumption, stability, sustainability, etc.) and components (quality, quantity, local preferences, cultural acceptability, etc.) [41–43]. Particularly at the household level, various indicators are presently been employed for evaluation, monitoring, analysis, etc. [44,45]. However, food security assessments at household level remain a challenge as the term "household" is still subjected to varying interpretations and its composition also varies. Selecting appropriate indicators for analyzing different dimensions of food security at different scales is also recognized as a serious challenge [46]. Also, food insecurity has for long been viewed from the perspective of rural population only. However, in the recent years, there has been a growing recognition for this issue in context of urban population [47].

2.3. Importance of Urban–Rural Partnerships for Enhancing Food Security in Context of India

Fostering partnerships between urban and rural areas is important for sustainable development, as they are closely linked through a range of spatial and sectoral linkages, including food supply [48]. Urban areas have traditionally been reliant on surrounding peri-urban and rural areas to meet their fresh food demands. However, the conventional urban–rural food linkages are increasingly stressed due to the fast-growing urban population, rapid urbanization, industrialization, etc. [17,49]. Lately, the industrial supply chains have started to dominate the food markets by maintaining a steady supply of processed food with higher standards [18].

In the present context of COVID-19 in India, the GoI has assured a wide distribution of food grains at affordable prices [50], through the established Public Distribution System (PDS) and large buffer stocks maintained under the National Food Security Act 2013 (explained by Pillay and Kumar [51]). However, it is important to note that the PDS system is supplemental in nature, and there are already substantial challenges related to food supply and distribution in India [52–55]. Notably, Reardon et al. [56] pointed that the PDS system caters to only 5% of all purchased food in India, and the remaining 95% of purchased food is sold by private sector. The study also indicated that 60% of the food consumption in India is centered in urban areas, and the growing food demands are increasingly being met by long urban–rural supply chains. Following the enforced mobility restrictions and disrupted food supply chains, the ongoing COVID-19 pandemic has therefore created a sense of food insecurity in urban centers [57]. However, very limited research has thus far been done to understand the food insecurity issues in context of urban areas in India (e.g., [58,59]).

Recently, the importance of urban–rural partnerships has gained high prominence [60], especially after the global policy agreements, namely Sustainable Development Goals "SDG" [61] and The New Urban Agenda [62]. Goal 11 (Target 11.A) of the SDGs specifically emphasizes on strengthening the urban–rural linkages from a regional planning perspective. The United Nations Human Settlement Programme (UN-Habitat) [62] also defined key entry points to foster urban–rural linkages for implementing The New Urban Agenda through integrated development planning.

3. Materials and Methods

3.1. Case Study Area of Nagpur, India

Nagpur, also called the Orange city, is one of the most prominent urban agglomerations of central India (location shown in Figure 1). It is the third largest city (after Mumbai and Pune) and the winter capital of Maharashtra state. Spread over an area of 217.56 square kilometers, the city has a population of nearly 2.5 million [63]. Nagpur Municipal Corporation (NMC) serves as the local governance body that administers the city area. NMC has divided the city into 10 zones, which are further sub-divided into 38 wards [64]. Due to its strategic geographical location and rich natural resource base, Nagpur is projected to be one of the fastest growing cities in the world from 2019 to 2035 with an average Gross domestic product (GDP) growth rate of 8.41% [65].

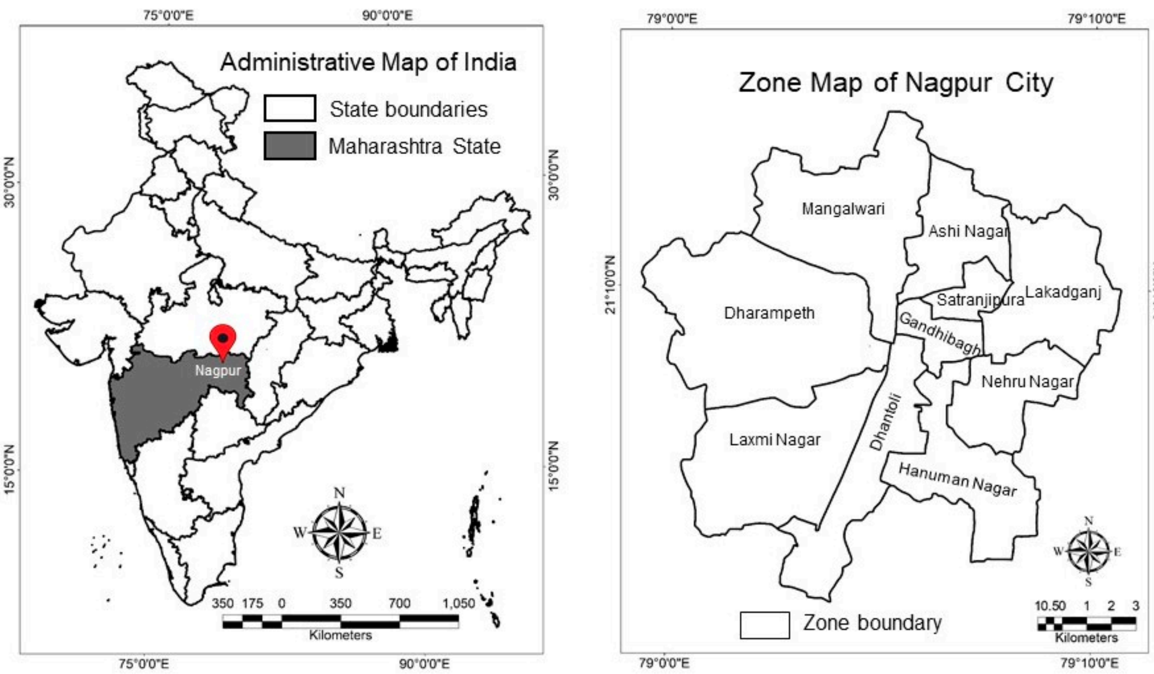

Figure 1. Location Map of Nagpur city in Maharashtra State of India (Image source: Author).

Nagpur city recorded its first confirmed case of COVID-19 on 12 March 2020. As of 1 August 2020, the city had recorded a total of 3645 confirmed cases [31]. Because of the steadily rising number of confirmed cases, the city is identified as one of the COVID-19 hotspots in central India.

3.2. Research Methods

3.2.1. Formal Interviews with Local Government Officials in Nagpur

In early April 2020, formal interviews were conducted with the government officials from Nagpur Municipal Corporation (NMC) and Nagpur District Collectorate Office, who are specifically dealing with COVID-19 response in Nagpur city and Nagpur district. The secondary information regarding the governance initiatives that were taken to manage the COVID-19 pandemic in Nagpur was gathered based on following three research questions: “What were the chronological implications of COVID-19 outbreak on local food systems?”; “Are there any specific concerns pertaining to continuity of urban–rural food supply chains in Nagpur?"; and "What kind of governance initiatives and measures are being taken for managing the local food systems?". Based on their responses, a precise understanding of ongoing pandemic outbreak in Nagpur was established. Although there are limitations to the information gathered through these questions, it is important for understanding the ongoing state of affairs as the city residents stay confined to their homes due to the enforced COVID-19 lockdown. To overcome the knowledge gaps, the authors have also referred to the NMC COVID-19 Control Room data and the daily media reports.

3.2.2. Online Surveys to Assess the Perception of Nagpur City Residents

As the local governments in Nagpur work to manage the implication of COVID-19 under the lockdown situation, the home-confined city residents receive extensive information about the availability of life essentials such as food grains, vegetables and healthcare products from a wide range of online and media sources. However, the circulation of fake information regarding the spread of infections or decline in market availability holds the potential to trigger any unforeseen concerns for food security. In that regard, it becomes important to understand the perception of Nagpur city residents for three key aspects: (1) Key Information Sources; (2) Immediate Concerns; and (3) Household Food security. While the local governments in Nagpur have reportedly taken several measures to maintain a continued food supply, this study tried to understand their effectiveness through the assessment of above-mentioned three key aspects.

Table 1 highlights the main research questions that were framed for understanding the "Key Information Sources" and the "Immediate Concerns" of Nagpur city residents during the pandemic situation. Acknowledging the widespread COVID-19 related concerns and the varied sources of information, the research questions were framed to determine the overall importance of the range of information sources (through multiple choice questions), as well as their individual significance (through single choice questions).

Table 1. Research Questions for assessment of "Key Information Sources" and "Immediate Concerns".

Key Determinant	Research Question	Response Options
Key Information Sources	What are your key sources of information for ongoing COVID-19 situation in Nagpur? (Multiple choice)	Television and Radio/Newspapers/Social Media/Governments websites and Apps/Phone calls and Messages/Community Networks/Official Communications/Others
	What is the most accurate and reliable source of information regarding COVID-19?	
Immediate Concerns	What are your immediate concerns in the wake of COVID-19 Pandemic scenario? (Multiple choice)	Health Services/Job Stability/Travel and Transportation/Food and Grocery/Water and Energy/Access to banking facility/Education/Social Interaction/Others
	What is your topmost concern at the moment under COVID-19 pandemic situation?	

In reference to the range of indicators established in previous studies (as discussed in Section 2.2), the developed framework mainly builds on four key dimensions of food security: (1) availability (in-house and market availability); (2) accessibility (physical and economic access); (3) consumption (food quality and local preferences); and (4) stability (anticipated impacts on food security). These are further categorized into 12 indicators. With an objective to understand the effectiveness of local government initiatives in maintaining household food security, specific research questions were framed to assess the defined indicators (as shown in Table 2) at household level. These research questions were supported with a set of predictable reactions to their experience of food insecurity, which could later be summarized and quantified for assessing the perceived food insecurity of survey respondents at household level.

Table 2. Indicators for assessing the perceived household food security under COVID-19 lockdown.

Food Security Determinant and Key Indicators	Research Question	Response Options
Food Availability		
1. In-house Availability	Do you grow your own fruits and vegetables in a homestead garden or plot? Do you own any livestock, farm animals or poultry?	Yes/No
2. Market Availability	In the past few weeks, how has the market availability of food products (including Fruits and Vegetables, Grains, Dairy Products, Meat and Poultry, Seafood) changed?	Highly Increased/Increased/No Change/Decreased/Highly Decreased
3. Current Stock	In the case of complete lockdown, for how many days will your current food stock be adequate?	Less than two days/Up to 1 week/Up to 2 weeks/More than 2 weeks
Food Accessibility		
4. Physical Access	Presently, do you have easy access (within 2 km) to nearby markets or grocery stores?	Yes/No
5. Market Prices	Has there been any change in food prices recently?	Highly Increased/Increased/No Change/Decreased/Highly Decreased
6. Institutional Support	Presently, do you have the facility to get food delivered at you houses?	Yes/No/Maybe
Food Consumption		
7. Nutritional Adequacy	Presently, do you have adequate access to nutritious food?	Yes/No/Maybe
8. Local Preferences	Has there been any shortage of your preferred food products?	Yes/No
9. Food Quality	In the past few weeks, has the quality of food products matched your expected levels?	Yes/No
Food Stability		
10. Food Supply	Do you think the supply of food products will be stable in coming weeks?	Yes/No/Maybe
11. Food Prices	Do you think food products will be affordable to you in coming weeks?	Yes/No/Maybe
12. Information Access	Do you have reliable access to information related to availability of food products in markets?	Yes/No

To study the perception of Nagpur city residents for the defined research questions of three key aspects, the authors conducted online surveys (through Google Forms) at two different time intervals. The online mode was specifically selected in consideration to the core need of maintaining social distancing and avoiding any unintended consequences of this study. Each of the two surveys was conducted specifically for five days, in due consideration to the fast-changing situation of COVID-19 and related concerns. After the defined period of five days, the online survey was turned off, and the survey responses were downloaded as csv file. Thereafter, the collected data were analyzed by the authors in Microsoft Excel (Microsoft; Seattle, WA, USA).

The first survey was conducted during the initial phase of COVID-19 outbreak in Nagpur (22–26 March 2020). This survey, conducted during the early phase of COVID-19 outbreak, mainly assessed the two key aspects of “Key Information Sources” and “Immediate Concerns”. The survey form was randomly circulated by the authors amongst the Nagpur city residents, through various social media platforms including Facebook and Whatsapp. All the respondents in the first survey were asked for their willingness to participate in the second (follow-up) survey.

The second survey was conducted during the peak-building phase (two weeks after complete lockdown at National level) from 5 to 9 April 2020. To build on the results obtained through the initial survey, the second survey was specifically conducted with the respondents of first survey who had expressed their willingness to participate. The online questionnaire for the second survey was circulated to the interested respondents, through emails and phone numbers received during initial phase survey. In addition to the key aspects of “Key Information Sources” and “Immediate Concerns”, this survey also assessed the perceived food security of the survey respondents at household level.

The initial phase survey questionnaire mainly consisted of four key research questions related to the “Key Information Sources” and “Immediate Concerns” of Nagpur city residents (as shown in Table 1). In addition to these, the peak-building phase survey questionnaire consisted of 13 other research questions related to food security assessment at household level (as shown in Table 2). For the aspects of “Key Information Sources” and “Immediate Concerns”, the results from two online surveys are intended to assess the change in perception of survey respondents at two different time intervals. Further, the food security assessment in the peak-building phase is mainly intended to understand the extent to which the local government initiatives have been effective to provide a secure food environment for the home-confined city residents, under the unprecedented COVID-19 lockdown situation.

Lastly, the survey respondents were also asked about some general details (age, gender, area of resident, occupation and key food purchase areas). To create low respondent burden and ensure wider participation from the city residents, the survey questions were specifically related to ongoing COVID-19 pandemic, and other specific questions such as household income, etc. were excluded.

4. Results

4.1. Emergence of COVID-19 Pandemic in Nagpur and Local Government Response

Based on the formal interviews with local government officials, the initial rise in the number of COVID-19 confirmed cases was observed as intermittent spikes (as illustrated in Figure 2). In reference to the three spikes of COVID-19 outbreak in Nagpur that were observed between 12th March and 18 April 2020, a month-long timeline of COVID-19 pandemic outbreak was developed. Based on the insight gained through the formal interviews, the chronological implications of COVID-19 in Nagpur, the consequent government initiatives to control the spread of infections and maintaining the food supply are descriptively explained in the following three subsections.

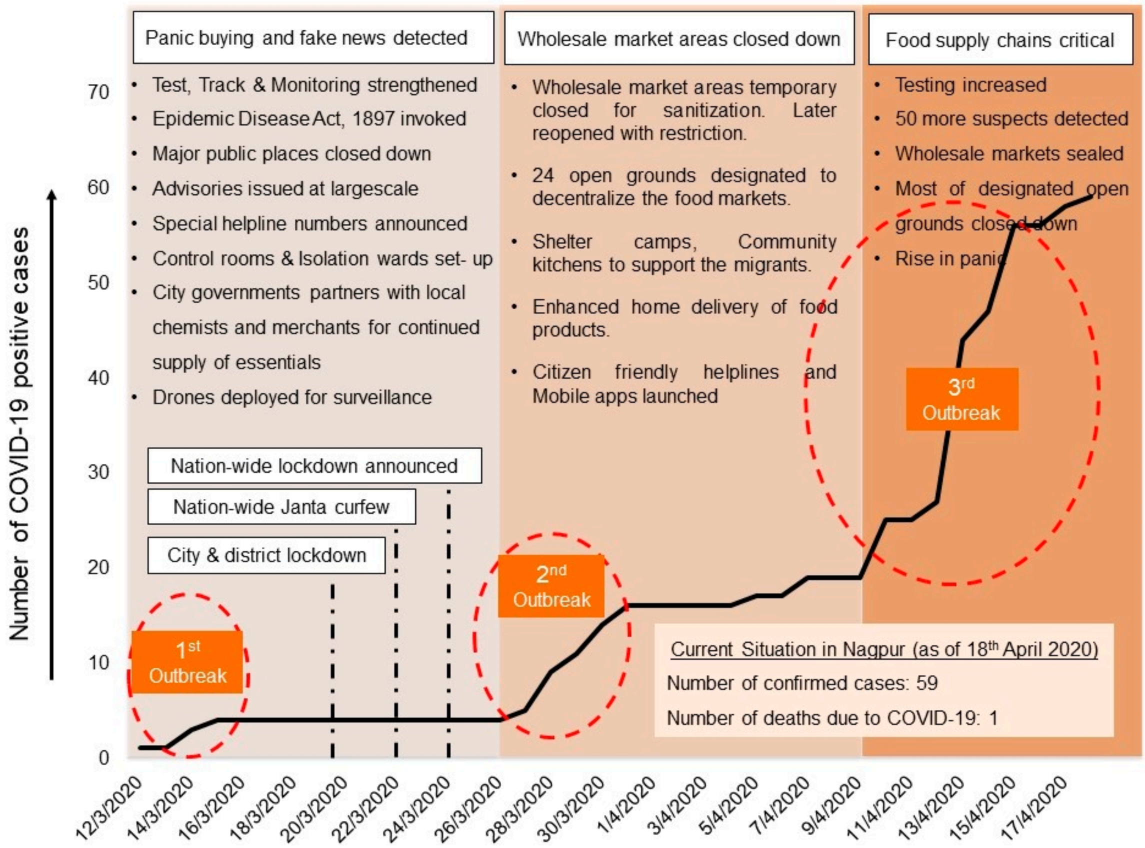

Figure 2. Timeline of COVID-19 outbreak in Nagpur, its chronological implications and Government response measures (prepared by the authors in reference to the COVID-19 Monitoring Dashboard maintained by Public Health Department, Government of Maharashtra [31]).

4.1.1. First Wave of Pandemic Outbreak and Panic Buying

After the emergence of COVID-19 patients in the city, a panic buying of healthcare products such as hand sanitizers and facemasks was witnessed. To control that, the provisions of the Epidemic Diseases Act [66] were extended and the shopping malls in the city were closed. The imposition of stricter regulations forbidding gathering of people in public areas affected the movements of contract staff in the malls, daily wagers and laborers, including those who were working in the freight transportation and food market sector. However, the life essential services including pharmacy, grocery stores, vegetable shops, milk booth, daily needs shops, etc. continued to operate with strict measures to maintain "social distancing" among the citizens.

After a nationwide lockdown from 24 March was announced by the Government of India [20], all the public transportation modes including roads and railways came to a standstill. The perishable goods that were reaching the city from adjoining states and rural areas as well as those which were being exported from the city through passenger trains also stopped reaching the markets. The farm produce that reaches the markets through roadways also witnessed a temporary blockade after the district boundaries were sealed by civic authorities. The already ongoing shortage of labor in market and reduction in supply of commodities led to an increase in retail market prices forcing the local government authorities to ease the freight movements of basic commodities.

To ensure continued provisioning of life saving drugs and medicines to the citizens, NMC entered into a partnership with local Chemists Association and identified 12 medical stores that would remain open 24 × 7, in addition to other medical stores, which operated within limited hours during the lockdown. Likewise, NMC also tied up with 45 local merchants and shopkeepers for providing home delivery of grocery items across majority of zones in the city. For stricter implementation of the lockdown regulations, NMC also deployed drones for surveillance of key public areas to identify the violators as well as those needing shelter assistance in the city [67].

4.1.2. Second Wave of Pandemic Outbreak and Closure of Wholesale Markets

After containing the spread of novel coronavirus for 11 consecutive days (as also evident in Figure 2), the city witnessed a second spike of COVID-19 confirmed cases on 26 March, as the number of COVID-19 positive patients quadrupled in four days. The local authorities again sprang into action to stop the spread of infections and closed down the wholesale market areas that were attracting large gatherings of farmers, traders, retailers and buyers. The Agriculture Produce Market Committee (APMC) yard at Kalamna, the biggest wholesale market for grains and vegetables in the city and that distributes the commodities all over the city, was closed for sanitization. Thereafter, a sense of insecurity for livelihoods prevailed amongst the farmers and traders, as there were no clearer directions and alternatives from the civic authorities for making the sale. Thereafter, to maintain a continued supply of food produce with safety precautions, the local authorities took three key initiatives as explained below:

1. Designated open grounds to decentralize the food markets: In coordination with APMC, the city authorities designated 24 open grounds in different parts of the city as alternative locations to carry out the sale transactions between traders and associated farmers. Such decentralization of the wholesale market was done to control overcrowding and to avert the community spread of novel coronavirus (schematic explanation shown in Figure 3). However, reportedly, only seven of the 24 designated open grounds were occupied by the farmers and traders due to a variety of stated reasons such as lack of proper facilities, limited spaces, the long distances and transportation costs. Resultantly, several farmers were forced to sell their produce on streets at much-reduced prices, and many others preferred selling their produce outside the city.
2. Shelter camps and community kitchens for the needy people: In reference to NMC COVID-19 Control Room data, Nagpur city started witnessing panic amongst the labor class migrants from 29th March onwards, as they started crossing the city by foot defying the lockdown regulations Under the directive of the National and State Governments, the City and District authorities set up 19 shelter homes and 177 relief camps to cater to the needs of about 5685 people (as on 8 April 2020). Furthermore, around 28 community kitchens [68] were established to meet the food demands of 29,050 people accommodated in temporary tents, hostels and other relief camps.
3. Home delivery of food products: To create redundancies in food supply and provide door-to-door service, the local authorities partnered with around 50 Food Produce Organizations (FPOs) from the surrounding rural areas, comprised of small and medium farm holding agriculture producers and farmers registered under various governmental schemes. The local authorities in coordination with youth voluntary groups also launched a helpline number for vulnerable groups (e.g., the elderly and physically challenged people), through which they can receive home delivery of essential commodities from associated retail shops. To further promote the initiatives of home delivery and make it citizen friendly, a web-based application [69] was also launched by the authorities.

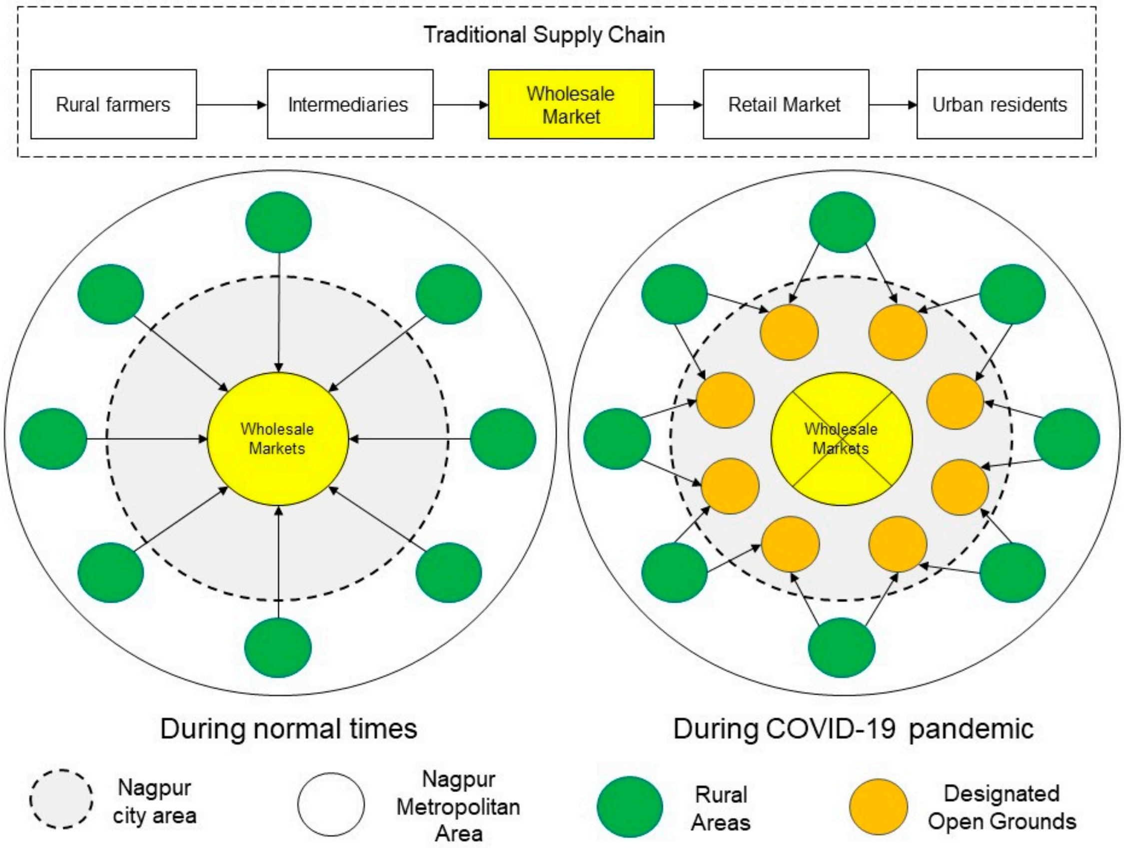

Figure 3. Implications of COVID-19 on traditional food supply chain in Nagpur (Image source: the authors).

4.1.3. Third Wave of Pandemic Outbreak and Disruption of Food Supply Chain

On 7 April, the city registered its first death due to COVID-19. With the information of travelers arriving from the national capital, one of the main hotspots of COVID-19, the city government geared up for increasing their testing capacities and established four more centers on 9 April. With increased testing capacities, the number of COVID-19 positive patients in the city also increased and tripled over a week's time. It was a matter of huge concern for the city administration, as the rapid outbreak was observed in the areas close to grains wholesale market, which then had to be sealed as per the standard operating procedures. On the other hand, just as the farmers and traders had adjusted after 10 days in the designated open grounds for food marketing, the city government again declared that five of the seven operating make-shift markets must close on 11th April. The frequent shifting of the markets started creating confusion amidst the retail shopkeepers, vendors, and common citizens regarding availability of the vegetables during critical times.

4.2. Key Information Sources, Immediate Concerns and Perceived Food Security at Household Level

In total, 346 responses were received for the initial phase survey, and for the peak-building phase survey (follow-up survey) 88 of these respondents had expressed their willingness and participated for the same. It is important to note that the initial survey was conducted with randomly selected individuals from the city, for a specific period of time. Therefore, the contacted sample does not represent the demographic characteristics of the overall city population. The respondents for peak-building phase survey are also comparatively fewer than those of the initial phase survey. However, it may be due to the fixed time duration and the follow-up approach of this study.

The results obtained through the initial phase surveys serve as a foundation over which the change in perception of survey respondents for "Key Information sources" and "Immediate Concerns" during the peak-building phase are assessed. In addition, the perceived food security at household level was assessed during the peak-building phase to understand the effectiveness of food-related governance initiatives that were taken during the lockdown situation.

Table 3 highlights the characteristics of survey respondents during both the online surveys conducted. As is evident, a variety of respondents from different age, gender and occupation groups from all ten zones of Nagpur city (Figure 1) participated in the online surveys. The interpretation of study results is done in the form of percentages.

Table 3. Characteristics of survey respondents.

Respondent Characteristics	**Initial Phase (22nd March to 26th March 2020)**	**Peak-Building Phase (5th April to 9th April 2020)**
Number of Surveys	346	88
Age Group of Respondents		
Under 20 Years	3.8%	2.3%
20s	34.7%	29.5%
30s	18.8%	20.5%
40s	14.5%	23.9%
50s	19.7%	21.6%
60 Years and Above	8.7%	2.3%
Gender Group of Respondents		
Male	43.9%	47.7%
Female	56.1%	52.3%
Other	0.0%	0.0%
Prefer Not to Answer	0.0%	0.0%
Area of Residence (categorized in 10 Zones of city)		
Laxmi Nagar	36.1%	40.9%
Dharampeth	23.4%	30.7%
Hanuman Nagar	11.6%	5.7%
Dhantoli	6.6%	2.3%
Nehru Nagar	2.9%	2.3%
Gandhibagh	3.2%	4.5%
Satranjipura	1.4%	3.4%
Lakadganj	3.5%	1.1%
Ashi Nagar	2.9%	2.3%
Mangalwari	8.4%	6.8%
Occupation Group of Respondents		
Government Service	15.0%	26.1%
Private Job	26.0%	31.8%
Formal Business	9.5%	12.5%
Informal Business	2.0%	2.3%
Student	26.6%	15.9%
Home Manager	9.8%	5.7%
Other	11.0%	5.7%

4.2.1. Key Information Sources Related to COVID-19 Pandemic

Figure 4 highlights the "Key Information Sources", as identified by the survey respondents during the initial and peak-building phase surveys. A considerable variation in community preferences for different information sources was observed. The importance of "Government Apps and Websites" and "Official Communications" particularly increased during the peak-building phase. These results are mainly interpreted in the context of the enforced lockdown situation during the peak-building phase.

While the responding city residents are confined to their homes, they appear to be primarily reliant on the incoming information from government agencies, who are managing the overall situation at large scale. On the other hand, the comparative significance of "Social Media" and "Newspapers" was observed to be declining during the peak-building phase. These results may be attributed to the growing incidents of fake news circulation through social media platforms and the fear of print newspapers being a potential virus carrier. Overall, "Television and Radio", "Newspapers", "Social Media" and "Government websites and Apps" were identified by the survey respondents as their key information sources (more relevant than others) during both surveys. Apart from these, other less recognized sources specified by the respondents under the "Others" category included informal information sources such as medicine stores and pharmacists.

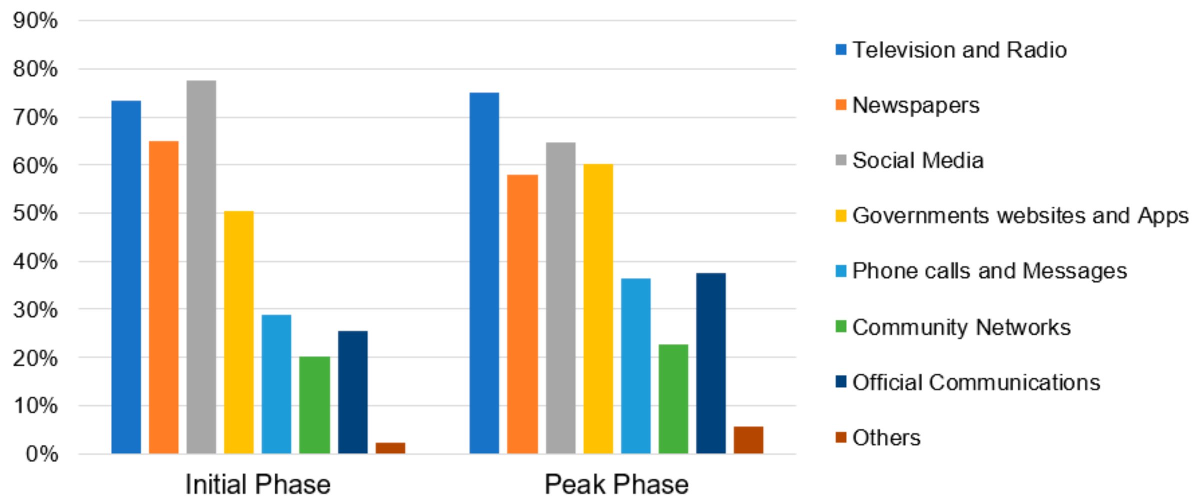

Figure 4. Key Information Sources identified by the survey respondents for COVID-19.

Among the various information sources, Figure 5 highlights the most accurate and reliable source of information identified by the survey respondents during the initial and peak-building phase surveys. Since the surveys were conducted only through online mode due to the lockdown restrictions, there is a possibility of these results to be more relevant for those who use online sources. Within the selected subset of online survey respondents, the "Government websites and Apps" followed by "Television and Radio" were identified as the most reliable sources for COVID-19 related information, specifically for the availability of the life-essential services including food. The comparative decline in the importance of "Social media" and "Newspapers" during the peak-building phase survey is also evident in this figure.

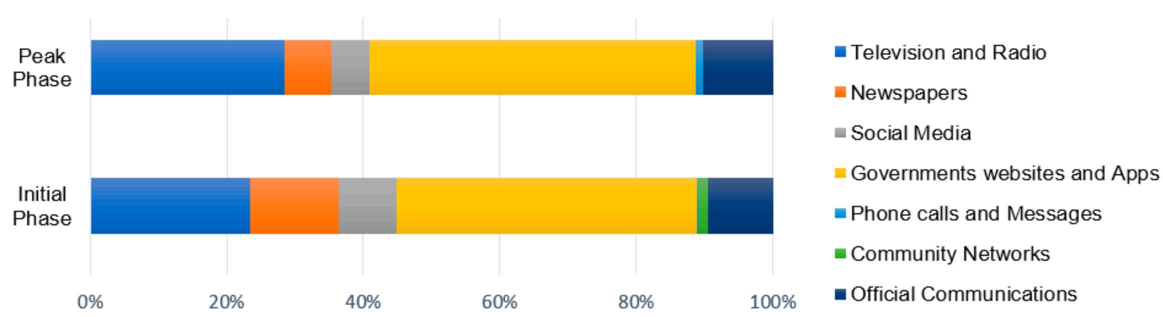

Figure 5. Most reliable source of information identified by the survey respondents for COVID-19.

4.2.2. Immediate Concerns Due to COVID-19 Pandemic

Figure 6 highlights the "Immediate Concerns" identified by the survey respondents during the initial and peak-building phase surveys. During both the stages, "Health services" was identified to be the most immediate concern for majority of the respondents. The concern was particularly higher in the peak-building phase, which is supposedly due to the rising cases of COVID-19 infections in the city. Further, "Food and Grocery" was identified to be the second immediate concern. Noticeably, its importance grew significantly during the peak-building phase survey, as more than 60% of respondents highlighted it to be an immediate concern. This result is presumed to be associated with the abrupt closing and shifting of vegetable wholesale markets, disruption of supply chain of food grains and grocery, etc. that were also being reported in the news media. Although less significant, the survey respondents also identified other immediate concerns such as "Social interaction", "Travel and transportation", "Job stability", "Education", etc.

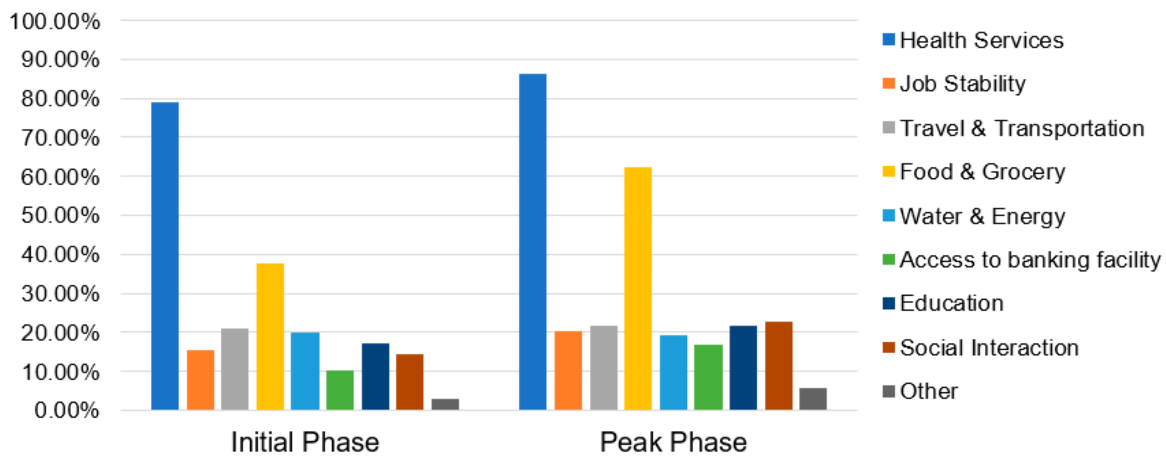

Figure 6. Immediate concerns identified by the survey respondents during COVID-19 lockdown.

Among the range of Immediate concerns, Figure 7 highlights the topmost concern identified by the survey respondents during the initial and peak-building phase of COVID-19. The comparative significance of "Food and Grocery" related concern was found to have risen significantly in the peak-building phase survey, in parallel to "Job stability" and "Education". Notably, the concerns of "Social Interaction" and "Travel and Transportation" were less significant during the peak-building phase. This comparative decrease in significance may possibly be the result of strict lockdown situation and growing awareness for maintaining social distancing to prevent the spread of COVID-19 pandemic.

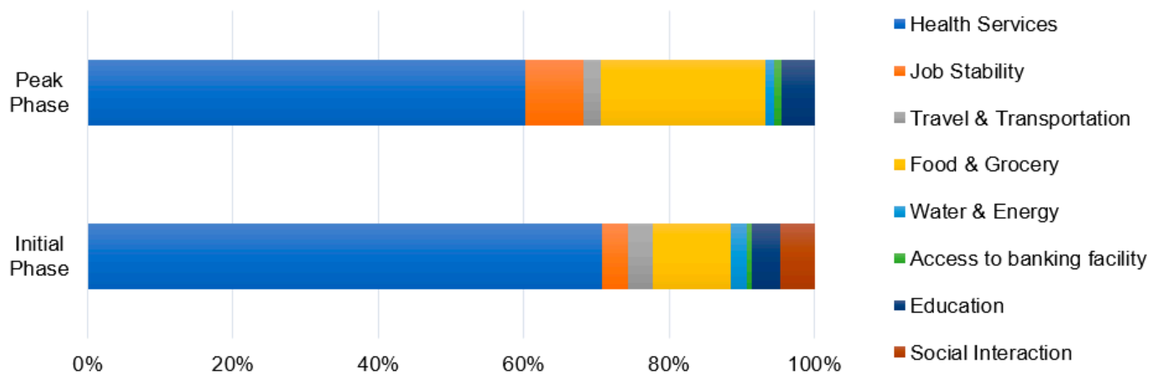

Figure 7. Topmost concerns identified by the survey respondents during COVID-19 lockdown.

4.2.3. Perceived Food Security at Household Level

At the outset, it is important to highlight that 86.4% of the survey respondents stated their dependence on the retail market (supermarket, street markets, vendors, etc.) for meeting their food demands, which is very high compared to other sources such as wholesale market (5.7%), intermediaries (5.7%) and farmers (2.3%). These results particularly highlight the high dependence of Nagpur city residents on food purchased from the formal and informal markets, which despite creating redundancy for food supply at local level are highly dependent on centralized wholesale markets. Table 4 further highlights the survey results for defined indicators of perceived food security at household level during the peak-building phase surveys (under the lockdown situation).

Table 4. Perceived household food security of survey respondents during the peak-building phase.

Food Security Determinant and Key Indicators	Research Question	Response Options—Response Percentage
	Food Availability	
In-House Availability	Do you grow your own fruits and vegetables in a homestead garden or plot?	Yes—19.3% No—80.7%
	Do you own any livestock, farm animals or poultry?	Yes—1.1% No—98.9%
Market Availability	In the past few weeks, how has the market availability of food products (including Fruits and Vegetables, Grains, Dairy Products, Meat and Poultry, Seafood) changed?	Highly Increased—4.5% Increased—9.1% No Change—36.4% Decreased—43.2% Highly Decreased—6.8%
Current Stock	In the case of complete lockdown, for how many days will your current food stock be adequate?	Less than two days—5.7% Up to One week—31.8% Up to Two weeks—33% More than 2 weeks—29.5%
	Food Accessibility	
Physical Access	Presently, do you have easy access (within 2 km) to nearby markets or grocery stores?	Yes—98.9% No—1.1%
Market Prices	Has there been any change in food prices recently?	Highly Increased—9.1% Increased—61.4% No Change—28.4% Decreased—1.1% Highly Decreased—0%
Institutional Support	Presently, do you have the facility to get food delivered at you houses?	Yes—39.8% No—25% Maybe—35.2%
	Food Consumption	
Nutritional Adequacy	Presently, do you have adequate access to nutritious food?	Yes—87.5% No—12.5%
Local Preferences	Has there been any shortage of your preferred food products?	Yes—38.6% No—61.4%
Food Quality	In the past few weeks, has the quality of food products matched your expected levels?	Yes—69.3% No—30.7%
	Food Stability	
Food Supply	Do you think the supply of food products will be stable in coming weeks?	Yes—38.6% No—19.3% Maybe—42%
Food Prices	Do you think food products will be affordable to you in coming weeks?	Yes—46.6% No—18.2% Maybe—35.2%
Information Access	Do you have reliable access to information related to availability of food products in markets?	Yes—68.2% No—31.8%

1. Food Availability: The city residents were found to be highly dependent on food markets, as very low percentages of respondents stated growing their own fruits and vegetables (19.3%) or own any livestock, farm animals or poultry (1.1%). Against the growing disruptions in food supply and relocation of food markets, around 50% of the survey respondents have witnessed a decrease in market availability of food products (mainly "Food and Vegetables" and "Meat and Poultry"). Although the survey respondents were found to have maintained adequate stock of food grains and grocery, most (around 70.5%) could satisfy their needs up to only two weeks in the case of a complete lockdown.
2. Food Accessibility: Most survey respondents (98.9%) were found to have easy access to nearby markets or grocery stores. However, due to the strict containment measures, the markets and grocery stores were opening only for stipulated hours every day. While 39.8% of survey respondents were stated to have access to food delivery services, the majority of respondents were still required to compulsorily visit the markets for purchasing their food products. Notably, 35.2% of respondents were not aware if they even have any access to home delivery services for food. Against the frequent disruptions in food supply chains that resulted in a limited stock with the retailers and vendors, more than 70% respondents reported an increase in food prices (particularly for fruits and vegetables) in the wake of COVID-19 outbreak. These results also substantiate the earlier finding of declining market availability of food products.
3. Food Consumption: Overall, 87.5% of respondents were found to have adequate access to nutritious foods. However, 38.6% of the survey respondents reportedly experienced shortage of their preferred food products in the market. While most food products are sourced from the rural areas around the city, it is important to note that the "Fruits and Vegetables" are perishable food commodities, which need adequate storage and processing. It was also found that the food quality has recently not matched the expected levels of 30.7% respondents. This may be associated with the shortage created due to panic buying phenomenon observed in the initial phase of the outbreak and also the shopkeepers opening up their reserved stock of the goods.
4. Food Stability: While Nagpur city residents usually depend on the informal food markets, the emergence of COVID-19 pandemic has led to a sense of uncertainty about the stability of food supply. It was found that only 38.6% respondents think that the food supply will be stable, while only 46.6% of respondents think they can afford the food products in the coming weeks. Even more concerning is the fact that a significant proportion of people are not sure about the stability of food supply (42%) or their ability to afford the food products (35.2%) in the coming weeks. Further, 31.8% of the respondents believe that they do not have reliable access to information related to availability of food products in markets.

5. Discussion

Similar to most cities around the world, Nagpur has also presently become a living laboratory. Unlike normal times, the management and governance of food systems is currently been coordinated by the local governments. With the aim to decongest the wholesale markets, various initiatives have been taken from closing down the wholesale market itself to designating city open grounds for wholesale vegetable trade, app-based home delivery, community kitchens, etc. However, the traditional food supply chains that connect Nagpur city to surrounding rural areas have been disrupted due to the closure of wholesale markets. The traders and farmers associated with the wholesale markets are also facing extreme difficulties in terms of limited spaces, financial constraints, manpower shortages, etc. As the pandemic continues to unfold, findings suggest that Nagpur city residents are also witnessing uncertainties in food supply along with the decline in market availability and increase in food prices. Based on the established understanding of pandemic situation in Nagpur (Section 4.1) and the results of online surveys (Section 4.2), the authors suggest specific policy recommendations for addressing the uncovered immediate concerns, as well as to strengthen the local food systems in the long-term.

5.1. Short-Term Policy Recommendations

5.1.1. Efficient Information Sharing Mechanisms to Avoid Panic among the Citizens

Reliable access to accurate information can play an important role in effectively managing the ongoing COVID-19 health emergency. As discussed in Section 4.1, the local government authorities in Nagpur have already put in operation several advanced technologies such as mobile apps, websites, helpline numbers, drones, etc. for various purposes including surveillance, food delivery, relief operations, etc. However, through the online surveys, the immediate concerns of "Food and Grocery" were found to be rising (Section 4.2.2) among the local citizens. Although there is a lack of supporting evidence, the rising concerns of "Food and Grocery" may inadvertently lead to changed consumer behaviors in terms of panic buying and stockpiling. To reduce any such uncertainties, it is important for the city residents to have reliable access to real-time information regarding the market availability of life essential services such as food commodities and healthcare products.

Based on the assessment of people's perception in Nagpur, "Government websites and apps" were found to be highly reliable and accurate source of information. While the local government are already making use of mobile apps and web-portals for COVID-19 related information sharing, the study results show that 31.8% of survey respondents (refer to Table 4) did not have reliable access to information related to market availability of food products. In view of the already existing online platforms and the outreach shortcomings identified through the study, the authors stress on strengthening these existing online platforms through effective information sharing and wider community outreach. In that manner, the local governments can timely reach out to citizens for tackling or avoiding any panic-driven response by the citizens.

5.1.2. Enhancing the Household Food Security through Robust Food Supply Chains

Several global research agencies including the UN, FAO, WHO, etc. have put forward specific guidelines to manage the wide-ranging implications of COVID-19, including those on food systems [70]. The steadiness of food supply chains has been recognized as the core need to avoid any potential food shortages or price hikes [71]. In the case of Nagpur, the closure of wholesale markets reportedly disrupted the urban–rural supply chains and raised serious concerns for various supply chain actors including the farmers and traders (discussed in Section 4.1.2). Based on the primary surveys, it has also been found that urban residents have recently witnessed food insecurity concerns such as declining market availability and increased food prices (refer to Table 4). It is therefore apparent that the robustness of traditional food supply chains in Nagpur needs to be strengthened for ensuring household food security, specifically as the food consumption is presently concentrated in the household. To achieve that, the local authorities should consider the development of a "business continuity plan" in close coordination with all the related actors including the farmers, traders, etc. As explained in Section 4.1.2, the local governments in Nagpur have already partnered with around 50 local FPOs for enhancing home delivery of food products. These partnerships should further be mobilized to create short and reliable food supply chains for long term.

5.2. Long-Term Policy Recommendations

Although COVID-19 pandemic continues to proliferate, cities around India (including Nagpur) are now easing the lockdown restrictions to alleviate the economic impacts. The local authorities in Nagpur have undeniably taken extraordinary steps to manage the local food systems during the lockdown situation. However, at the same time, there is a need for adopting certain long-term actions to mitigate the anticipated impacts of COVID-19 as well to prepare for the future pandemics. Based on the research findings and interaction with the local government officials, the authors postulate three specific policy recommendations for strengthening the local food systems.

5.2.1. Boosting Urban Agriculture and Local Food Production

As with most cities, Nagpur considerably depends on surrounding rural areas to meet their food demands, specifically for perishable products such as fruits and vegetables. Through the study results, only 19.3% of the survey respondents were found to grow their own fruits and vegetables (refer to Table 4). In the wake of COVID-19, a genuine need for enhancing urban agriculture and encouraging local food production has therefore been realized around the world to supplement the traditional food supply from rural areas [57,72,73]. To ensure sustainable food production and consumption at city level, the city governments should encourage the local residents to practice agriculture at neighborhood level. Several forms and practices of urban agriculture such as community gardens, farmer's market, green roofs, etc. were highlighted by Burton et al. [74]. Nicholls et al. [75] also underlined the importance of enhancing urban and peri-urban agriculture to achieve sustainable development. The many benefits of enhancing urban agriculture also include improved household food security [76] and urban resilience [77].

5.2.2. Integrated Governance of Food Systems at Regional Level

While Nagpur city provides the market for food supply, the bulk of it is produced in surrounding rural areas. It is therefore important to understand that food systems connect Nagpur city with the rural areas in wider metropolitan area. The importance of multi-level food system governance has for long been advocated to bring together a wide range of supply chain actors from producers to consumers [78]. Dubbeling et al. [16] also highlighted the importance of city-region perspective for building more resilient, fair, and sustainable food systems. However, the integrated governance of food systems is still not recognized at policy levels in Nagpur. Although the local governments in Nagpur are now coordinating with The Agriculture Produce Market Committee for managing the food systems in the wake of COVID-19 outbreak (discussed in Section 4.1.2), the study recommends for their continued engagement to leverage the urban–rural interdependencies and promote policy coherence at regional level. For the long-term sustainable development of Nagpur, the city essentially needs to be underpinned by strong urban–rural linkages, the importance of which has also been recognized through global policy frameworks such as SDGs and The New Urban Agenda.

5.2.3. Bridging the Urban–Rural Gaps through Improved Producer-Consumer Relationship

The closure of wholesale markets in Nagpur and the disruption of supply chains have brought forward the vulnerabilities of food systems in Nagpur. While rural farmers are reportedly experiencing increasing marginalization (Section 4.1.2), the high dependence of city residents on retail markets also makes them vulnerable to the concerns of food shortages and price hikes (as shown in Table 4). As such, there is a need for redundancies in the local food systems. Sukhwani et al. [17] explained how improved producer–consumer relationships can serve for narrowing the food supply demand gaps between urban and rural areas at regional level. In reference to the existing best practices, the local governments should adopt locally-relevant strategies for strengthening the food systems in long-term.

6. Conclusions

This paper presents an early assessment of COVID-19 implications on local food systems, with reference to the specific case of Nagpur in central India. The key purpose of the study was to understand the chronological implications of pandemic outbreak on local food systems and to determine the effectiveness of counteractive governance measures by examining the perception of home-confined Nagpur city residents. The study covered an important issue of perceived food security at the household level, as the city residents stay confined to their homes under the strict lockdown situation. It, therefore, provides an original contribution as only a few studies have so far addressed this issue in the context of a pandemic situation.

Through a descriptive analysis of city resident's "Key Information Sources" and "Immediate Concerns" in different time intervals of COVID-19 outbreak, a considerable variation in people's perception was observed. While the concerns of "Food and Grocery" were found to significantly increase in the lockdown phase (along with the concerns of health services), the survey respondents were found to prefer authentic sources of information such as "Government apps and websites" and "Official Communication". The assessment of perceived food security at household level also brought forward the key vulnerabilities in the local food systems, which could not be adequately addressed by the local governments in the lockdown phase.

Moreover, the dynamics of COVID-19 is still very complex, and the situation is constantly evolving by the day. It is therefore very hard to determine the significance of the study findings in long run. However, this study is hoped to serve as a strong foundation for effectively managing the local food systems against future pandemics. The paper describes the grassroot level situation based on formal interviews (with local government officials) and primary surveys (with city residents) at defined time intervals (March–April 2020). However, the statistics related to spread COVID-19 are already very different four months later in August 2020. The small sample size and the online mode of survey, necessitated by the strict lockdown situation in Nagpur, is one of the key limitations of this study. Due to the random sampling method, the study also could not incorporate the concerns of varied socioeconomic groups.

Towards the end, it is important to underline that the suggested policy recommendations are based on a precise understanding of the ongoing pandemic situation and the research findings derived through online surveys. The authors also acknowledge that the perceived household food security, immediate concerns and key information sources are bound to vary significantly between different socioeconomic groups, and there is need for further research to precisely understand the effectiveness of food-related governance initiatives in pandemic situation.

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References

1. Global Food Security Cluster (gFSC). *Coronavirus, Impact on Well-Being, Health, Food Access and Food Security*; gFSC: Rome, Italy, 2020; Available online: https://fscluster.org/sites/default/files/documents/covid_19_impact_on_food_security.pdf (accessed on 1 August 2020).
2. Johns Hopkins University (JHU). COVID-19 Dashboard by the Center for Systems Science and Engineering (CSSE). Available online: https://coronavirus.jhu.edu/map.html (accessed on 1 August 2020).
3. Hua, J.; Shaw, R. Corona virus (COVID-19) infodemic and emerging issues through a data lens: The case of China. *Int. J. Environ. Res. Public Health* **2020**, *17*, 2309. [CrossRef] [PubMed]
4. Klaus, I. Pandemics Are Also an Urban Planning Problem. Available online: https://www.citylab.com/design/2020/03/coronavirus-urban-planning-global-cities-infectious-disease/607603/ (accessed on 5 July 2020).
5. Djalante, R.; Shaw, R.; Dewit, A. Building resilience against biological hazards and pandemics: COVID-19 and its implications for the Sendai Framework. *Prog. Disaster Sci.* **2020**, *6*, 100080. [CrossRef]
6. Shaw, R.; Kim, Y.K.; Hua, J. Governance, technology and citizen behavior in pandemic: Lessons from COVID-19 in East Asia. *Prog. Disaster Sci.* **2020**, *6*, 100090. [CrossRef]

7. International Food Policy Research Institute (IFPRI). 2020 global food policy report: Building inclusive food systems. In *2020 Global Food Policy Report: Building Inclusive Food Systems*; International Food Policy Research Institute (IFPRI): Washington, DC, USA, 2020.
8. FAO; IFAD; UNICEF; WFP; WHO. *The State of Food Security and Nutrition in the World 2019, Safeguarding Against Economic Slowdowns and Downturns*; The Food and Agriculture Organization of the United Nations (FAO): Rome, Italy, 2019; Available online: http://www.fao.org/3/ca5162en/ca5162en.pdf (accessed on 1 August 2020).
9. Gandhi, V.P.; Zhou, Z.Y. Food demand and the food security challenge with rapid economic growth in the emerging economies of India and China. *Food Res. Int.* **2014**, *63*, 108–124. [CrossRef]
10. Chatterjee, R.; Rahman, A.U.; Tran, T.; Shaw, R. Urban food security in Asia. In *Urban Disasters and Resilience in Asia*; Elsevier BV: Oxford, UK, 2016; pp. 161–178.
11. World Food Programme (WFP). COVID-19 Will Double Number of People Facing Food Crises Unless Swift Action is Taken. Available online: https://www.wfp.org/news/covid-19-will-double-number-people-facing-food-crises-unless-swift-action-taken (accessed on 1 August 2020).
12. FAO. *World Food Prices Drop in March*; The Food and Agriculture Organization of the United Nations (FAO): Rome, Italy, 2020; Available online: http://www.fao.org/news/story/en/item/1269050/icode/ (accessed on 5 July 2020).
13. Petetin, L. The COVID-19 crisis: An opportunity to integrate food democracy into post-pandemic food systems. *Eur. J. Risk Regul.* **2020**, *11*, 326–336. [CrossRef]
14. UN Secretary-General/UN Sustainable Development Group. Policy Brief: The Impact of COVID-19 on Food Security and Nutrition. *The United Nations (UN)*. Available online: https://reliefweb.int/report/world/policy-brief-impact-covid-19-food-security-and-nutrition-june-2020 (accessed on 1 August 2020).
15. Matuschke, I.; Kohler, S. Urbanization and food security. In *WorldRiskReport 2014, Bündnis Entwicklung Hilft (Alliance Development Works), Bonn, Germany; United Nations*; University-Institute for Environment and Human Security (UNU-EHS): Berlin, Germany, 2014; Available online: https://i.unu.edu/media/ehs.unu.edu/news/4070/11895.pdf (accessed on 1 August 2020).
16. Dubbeling, M.; Santini, G.; Renting, H.; Taguchi, M.; Lançon, L.; Zuluaga, J.; De Paoli, L.; Rodriguez, A.; Andino, V. Assessing and planning sustainable city region food systems: Insights from two Latin American cities. *Sustainability* **2017**, *9*, 1455. [CrossRef]
17. Sukhwani, V.; Nurzaman, A.; Kusumawardhani, N.P.; Alhinai, A.M.; Hanyu, L.; Shaw, R. Enhancing food security by institutionalizing collaborative food alliances in urban areas. *Sustainability* **2019**, *11*, 4103. [CrossRef]
18. Hussein, K.; Suttie, D. IFAD research series 5–Rural-urban linkages and food systems in sub-Saharan Africa: The rural dimension. In *International Fund for Agricultural Development*; IFAD: Rome, Italy, 2016.
19. Laguna, L.; Fiszman, S.; Puerta, P.; Chaya, C.; Tárrega, A. The impact of COVID-19 lockdown on food priorities. Results from a preliminary study using social media and an online survey with Spanish consumers. *Food Qual. Prefer.* **2020**, *86*, 104028. [CrossRef]
20. UN News. *COVID-19: Lockdown Across India, in Line with WHO Guidance*; The United Nations (UN): New York, NY, USA, 2020; Available online: https://news.un.org/en/story/2020/03/1060132 (accessed on 4 July 2020).
21. Ward, A. *India's Coronavirus Lockdown and Its Looming Crisis, Explained*; Vox Media: New York, NY, USA, 2020; Available online: https://www.vox.com/2020/3/24/21190868/coronavirus-india-modi-lockdown-kashmir (accessed on 5 July 2020).
22. Government of India. #IndiaFightsCorona COVID-19. Available online: https://www.mygov.in/covid-19/ (accessed on 5 July 2020).
23. Pasricha, A. India Announces $265 Billion Package to Revive Battered Economy. Available online: https://www.voanews.com/covid-19-pandemic/india-announces-265-billion-package-revive-battered-economy (accessed on 4 July 2020).
24. Biswas, S. Coronavirus: India's Pandemic Lockdown Turns into a Human Tragedy. The BBC. Available online: https://www.bbc.com/news/world-asia-india-52086274 (accessed on 4 July 2020).
25. Hrishikesh, S. Coronavirus Lockdown: As Indians Begin Panic Buying, Govt Clarifies. HuffPost News. Available online: https://www.huffingtonpost.in/entry/coronavirus-lockdown-modi-speech-food-groceries_in_5e7a3229c5b6f5b7c54bc90e (accessed on 5 July 2020).

26. UN India. Nutrition and Food Security. United Nations (UN) India. Available online: https://in.one.un.org/un-priority-areas-in-india/nutrition-and-food-security/ (accessed on 4 July 2020).
27. Ritchie, H.; Reay, D.; Higgins, P. Sustainable food security in India—Domestic production and macronutrient availability. *PLoS ONE* **2018**, *13*, e0193766. [CrossRef]
28. Deliya, M.; Thakor, C.; Parmar, B. A Study on differentiator in marketing of fresh fruits and vegetables from supply chain management perspective. *Abhinav Natl. Mon. J. Res. Commer. Manag.* **2012**, *1*, 40–57.
29. Sihariya, G.; Hatmode, V.B.; Nagadevara, V. Supply Chain Management of Fruits and Vegetables in India. In Proceedings of the Tenth AIMS International Conference on Management, Bangalore, Indian, 6–9 January 2013; Indian Institute of Management (IIM): Bangalore, Indian, 2013. Available online: https://www.scribd.com/document/431976235/SupplyChainforFruitsandVegetables (accessed on 5 July 2020).
30. Mishra, K.; Rampal, J. The COVID-19 pandemic and food insecurity: A viewpoint on India. *World Dev.* **2020**, *135*, 105068. [CrossRef]
31. COVID-19 Monitoring Dashboard by Public Health Department, Government of Maharashtra. Available online: https://arogya.maharashtra.gov.in/ (accessed on 1 August 2020).
32. Béné, C. Resilience of local food systems and links to food security–A review of some important concepts in the context of COVID-19 and other shocks. *Food Secur.* **2020**, 1–18. [CrossRef]
33. Akter, S. The impact of COVID-19 related 'stay-at-home' restrictions on food prices in Europe: Findings from a preliminary analysis. *Food Secur.* **2020**, 1–7. [CrossRef]
34. Galanakis, C.M. The food systems in the era of the coronavirus (COVID-19) pandemic crisis. *Foods* **2020**, *9*, 523. [CrossRef]
35. FAO. *Rome Declaration on World Food Security and the World Food Summit Plan of Action, World Food Summit 13–17 November*; Food and Agriculture Organization of the United Nations (FAO): Rome, Italy, 1996.
36. Devereux, S.; Béné, C.; Hoddinott, J. Conceptualising COVID-19's impacts on household food security. *Food Secur.* **2020**, 1–4. [CrossRef]
37. Niles, M.T.; Bertmann, F.; Belarmino, E.H.; Wentworth, T.; Biehl, E.; Neff, R. The early food insecurity impacts of COVID-19. *medRxiv* **2020**, *12*, 2096. [CrossRef]
38. FAO. *An Introduction to the Basic Concepts of Food Security*; Food and Agriculture Organization of the United Nations (FAO): Rome, Italy, 2008; Available online: http://www.fao.org/3/a-al936e.pdf (accessed on 1 August 2020).
39. Mangnus, E.; Van Westen, A. (Guus) Roaming through the maze of maize in northern Ghana. A systems approach to explore the long-term effects of a food security intervention. *Sustainability* **2018**, *10*, 3605. [CrossRef]
40. Leroy, J.L.; Ruel, M.T.; Frongillo, E.A.; Harris, J.; Ballard, T.J. Measuring the food access dimension of food security. *Food Nutr. Bull.* **2015**, *36*, 167–195. [CrossRef] [PubMed]
41. Coates, J.; Swindale, A.; Bilinsky, P. *Household Food Insecurity Access Scale (HFIAS) for Measurement of Food Access: Indicator Guide (v.3)*; Food and Nutrition Technical Assistance III Project (FANTA): Washington, DC, USA, 2007.
42. Harris-Fry, H.; Azad, K.; Kuddus, A.; Shaha, S.; Nahar, B.; Hossen, M.; Younes, L.; Costello, A.; Fottrell, E. Socio-economic determinants of household food security and women's dietary diversity in rural Bangladesh: A cross-sectional study. *J. Heal. Popul. Nutr.* **2015**, *33*, 2. [CrossRef] [PubMed]
43. Sati, V.P. Enhancing food security through sustainable agriculture in Uttarakhand Himalaya. *Productivity* **2017**, *58*, 187–196.
44. Ike, C.U.; Jacobs, P.T.; Kelly, C. A multidimensional approach to measuring household food security in Taraba State, Nigeria: Comparing key indicators. *Dev. Pract.* **2017**, *27*, 234–246. [CrossRef]
45. Asih, D.N.; Klasen, S. Improving food security? Setting indicators and observing change of rural household in Central Sulawesi. *For. Soc.* **2017**, *1*, 154–161. [CrossRef]
46. Carletto, C.; Zezza, A.; Banerjee, R. Towards better measurement of household food security: Harmonizing indicators and the role of household surveys. *Glob. Food Secur.* **2013**, *2*, 30–40. [CrossRef]
47. Sisha, T.A.; Assefa, T. Household level food insecurity assessment: Evidence from panel data, Ethiopia. *Sci. Afr.* **2020**, *7*, e00262. [CrossRef]
48. Tacoli, C. Rural-urban interactions: A guide to the literature. *Environ. Urban.* **1998**, *10*, 147–166. [CrossRef]
49. Preiss, P.V.; Marques, F.C.; Wiskerke, J.S.C. (Han) Fostering sustainable urban-rural linkages through local food supply: A transnational analysis of collaborative food alliances. *Sustainability* **2017**, *9*, 1155. [CrossRef]

50. Kaur, G. India Launches the Biggest Food Ration Subsidy Scheme in the World Amid Coronavirus Lockdown. Grainmart News. Available online: https://www.grainmart.in/news/india-launches-the-biggest-food-ration-subsidy-scheme-in-the-world-amid-coronavirus-lockdown/ (accessed on 5 July 2020).
51. Pillay, D.P.K.; Kumar, T.K.M. Food security in India: Evolution, efforts and problems. *Strat. Anal.* **2018**, *42*, 595–611. [CrossRef]
52. Kumar, A.; Bantilan, M.C.S.; Kumar, P.; Kumar, S.; Jee, S. Food security in India: Trends, patterns and determinants. *Ind. J. Agric. Econ.* **2012**, *67*, 445–463. [CrossRef]
53. Ittyerah, A.C. Food Security in India: Issues and Suggestions for Effectiveness. In *Theme Paper for the 57th Members' Annual Conference*; Indian Institute of Public Administration: New Delhi, India, 2013.
54. Narayanan, S. Food security in India: The imperative and its challenges. *Asia Pac. Policy Stud.* **2015**, *2*, 197–209. [CrossRef]
55. Mahajan, S.; Sousa-Poza, A.; Datta, K.K. Differential effects of rising food prices on Indian households differing in income. *Food Secur.* **2015**, *7*, 1043–1053. [CrossRef]
56. Reardon, T.; Mishra, A.; Nuthalapati, C.S.R.; Bellemare, M.F.; Zilberman, D. COVID-19's disruption of India's transformed food supply chains. *Econ. Politic. Wkly.* **2020**, *18*, 18–22.
57. Lal, R. Home gardening and urban agriculture for advancing food and nutritional security in response to the COVID-19 pandemic. *Food Secur.* **2020**, 1–6. [CrossRef]
58. Chatterjee, N.; Fernandes, G.; Hernandez, M. Food insecurity in urban poor households in Mumbai, India. *Food Secur.* **2012**, *4*, 619–632. [CrossRef]
59. Anand, S.; Jagadeesh, K.; Adelina, C.; Koduganti, J. Urban food insecurity and its determinants: A baseline study of Bengaluru. *Environ. Urban.* **2019**, *31*, 421–442. [CrossRef]
60. Sukhwani, V.; Mitra, B.K.; Takasawa, H.; Ishibashi, A.; Shaw, R.; Yan, W. *Urban-Rural Partnerships: A Win-Win Approach to Realize Regional CES (Regional Circular & Ecological Sphere), Compendium of Good Practices from Japan*; Institute for Global Environmental Strategies (IGES): Japan, Yokohama, 2019; Available online: https://www.iges.or.jp/en/pub/urban-rural-partnerships-win-win-approach/en (accessed on 1 August 2020).
61. UNDP. Sustainable Development Goals (SDGs), United Nations Development Programme (UNDP). Available online: http://www.undp.org/content/undp/en/home/sustainable-development-goals.html (accessed on 1 August 2020).
62. UN-Habitat. Implementing the New Urban Agenda by Strengthening Urban-Rural Linkages-Leave No One and No Space Behind, United Nations Human Settlements Programme (UN-Habitat). Available online: https://unhabitat.org/books/implementing-the-new-urban-agenda-by-strengthening-urban-rural-linkages/ (accessed on 1 August 2020).
63. Deshkar, S. Resilience perspective for planning urban water infrastructures: A case of Nagpur City. In *Urban Drought: Emerging Water Challenges in Asia*; Ray, B., Shaw, R., Eds.; Springer Nature Singapore Pte Ltd.: Singapore, 2019; pp. 131–154.
64. Chakraborty, P. 10 Zones Restructured based on 38 Wards. The Times of India. Available online: https://timesofindia.indiatimes.com/city/nagpur/10-zones-restructured-based-on-38wards/articleshow/57741271.cms#:~{}:text=Accordingly%2C%20Laxmi%20Nagar%20zone%20will,02%2C%2003%2C%2006%20and%2007 (accessed on 1 August 2020).
65. Holt, R. Global Cities, Which Cities Will Be Leading the Global Economy in 2035? Oxford Economics. Available online: https://workplaceinsight.net/wp-content/uploads/2018/12/Global-Cities-Dec-2018.pdf (accessed on 1 August 2020).
66. Central Government Act- The Epidemic Diseases Act, 1897: Arrangement of Sections. Available online: https://indiankanoon.org/doc/1005961/ (accessed on 4 July 2020).
67. Smart Cities Mission (SCM). *Managing COVID-19, Good Practices in 100 Smart Cities, Smart Cities Mission (SCM)*; Government of India: New Delhi, India, 2020.
68. Mundhe, T. Nagpur Model for Food Security during #COVID-19. Available online: https://www.nexusofgood.org.in/stories/nagpur-model-for-food-security-during-covid19?fbclid=IwAR0wsQ3W46KA33rr_hRBuMyph5bFK_8dX_6KfkcwEqfEheaxN_8MCYZRry4 (accessed on 1 August 2020).
69. Order Online Home Delivery. An Initiative by Nagpur Municipal Corporation. Available online: http://covidcarenagpur.cdaat.in (accessed on 4 July 2020).

70. UNSCN. Recent News: The COVID-19 Pandemic is Disrupting People's Food Environments: A resource list on Food Systems and Nutrition responses. United Nations System Standing Committee on Nutrition (UNSCN). Available online: https://www.unscn.org/en/news-events/recent-news?idnews=2039 (accessed on 4 July 2020).
71. Cullen, M.T. *COVID-19 and the Risk to Food Supply Chains: How to Respond?* The Food and Agriculture Organization of the United Nations (FAO): Rome, Italy, 2020; Available online: http://www.fao.org/3/ca8388en/CA8388EN.pdf (accessed on 1 August 2020).
72. Pulighe, G.; Lupia, F. Food first: COVID-19 outbreak and cities lockdown a booster for a wider vision on urban agriculture. *Sustainability* **2020**, *12*, 5012. [CrossRef]
73. Loker, A.; Francis, C. Urban food sovereignty: Urgent need for agroecology and systems thinking in a post-COVID-19 future. *Agroecol. Sustain. Food Syst.* **2020**, 1–6. [CrossRef]
74. Burton, P.; Lyons, K.; Richards, C.; Amati, M.; Rose, N.; Des Fours, L.; Pires, V.; Barclay, R. *Urban Food Security, Urban Resilience and Climate Change*; National Climate Change Adaptation Research Facility: Gold Coast, Australia, 2013; p. 160. Available online: https://www.nccarf.edu.au/sites/default/files/attached_files_publications/Burton_2013_Urban_food_security.pdf (accessed on 1 August 2020).
75. Nicholls, E.; Ely, A.; Birkin, L.; Basu, P.; Goulson, D. The contribution of small-scale food production in urban areas to the sustainable development goals: A review and case study. *Sustain. Sci.* **2020**, 1–15. [CrossRef]
76. Diehl, J.A.; Oviatt, K.; Chandra, A.J.; Kaur, H. Household food consumption patterns and food security among low-income migrant urban farmers in Delhi, Jakarta, and Quito. *Sustainability* **2019**, *11*, 1378. [CrossRef]
77. Barthel, S.; Isendahl, C. Urban gardens, agriculture, and water management: Sources of resilience for long-term food security in cities. *Ecol. Econ.* **2013**, *86*, 224–234. [CrossRef]
78. FAO. *Food, Agriculture and Cities: Challenges of Food and Nutrition Security, Agriculture and Ecosystem Management in an Urbanizing World*; Food and Agriculture Organization of the United Nations (FAO): Rome, Italy, 2011; Available online: http://www.fao.org/fileadmin/templates/FCIT/PDF/FoodAgriCities_Oct2011.pdf (accessed on 1 August 2020).

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COVID-19 Response in Thailand and Its Implications on Future Preparedness

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Abstract: Thailand has been affected by COVID-19, like other countries in the Asian region at an early stage, and the first case was reported as early as mid-January 2020. Thailand's response to the COVID-19 pandemic has been guided by the "Integrated Plan for Multilateral Cooperation for Safety and Mitigation of COVID-19". This paper analyses the health resources in the country and focuses on the response through community-level public health system and legislative measures. The paper draws some lessons on future preparedness, especially with respect to the four priorities of Sendai Framework for Disaster Risk Reduction. At the end, the paper puts some key learning for future preparedness. While Thailand's response to COVID-19 has been effective in limiting the spread of the disease, it falls short at being able to address the multiple dimensions of the crisis such as the economic and social impacts. The socioeconomic sectors have been hardest hit, with significant impact on tourism sectors. Sociopolitical system also plays an important role in governance and decision-making for pandemic responses. The analysis suggests that one opportunity for enhancing resilience in Thailand is to strive for more multilevel governance that engages with various stakeholders and to support grassroots and community-level networks. The COVID-19 pandemic recovery is a chance to recover better while leaving no one behind. An inclusive long-term recovery plan for the various impacted countries needs to take a holistic approach to address existing gaps and work towards a sustainable society. Furthering the Health Emergency Disaster Risk Management (HEDRM) Framework may support a coordinated response across various linked sectors rather than straining one particular sector.

Keywords: COVID-19; Thailand health response; Sendai framework; inclusive recovery; HEDRM

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1. Introduction

The COVID-19 pandemic is a public health crisis without precedent in living memory, which is testing our collective capacity to respond" (OECD, 2020 [1]). Caused by SARS-CoV-2 (Severe acute respiratory syndrome coronavirus 2), the infectious COVID-19 (Coronavirus disease 2019) was first identified in Wuhan, China December 2019 and spread across the globe. At the time of writing, the pandemic is ongoing and has affected over 227 countries and territories [2]. The impact of COVID-19 in different countries has varied significantly due to factors including but not limited to governmental response, demographics, and healthcare infrastructure.

This paper focuses on the experience of COVID-19 pandemic in Thailand. As a popular destination for Chinese tourists, it was in Thailand that the first COVID-19 patient outside of China was identified on 13 January 2020. At the end of the same month, the first case of domestic transmission and the 16th patient in Thailand was identified. The number of COVID-19 patients remained relatively low until there was a rise in domestic infections in mid-March. A key event was a boxing match at the Lumpinee Boxing

Stadium, which took place on 6 March 2020 despite a ban on large gatherings that was put in place days before. It is estimated that 143 COVID-19 cases were directly linked to the boxing match [3]. In the days following the event, the number of new infections shot up to over a hundred per day.

Thailand's response to the COVID-19 pandemic has been guided by the "Integrated Plan for Multilateral Cooperation for Safety and Mitigation of COVID-19", which was drafted by the Ministry of Public Health for the following objectives: (1) Reducing the chances of the virus transmission into Thailand, (2) Everyone in Thailand and Thai people abroad are safe from COVID-19, (3) Mitigating the health, economic, social impacts and increasing national security. The Thai government provided daily updates on COVID-19 infections in Thailand via television and used the media to inform the citizens of new restrictions, safety precautions, and any other official news regarding the pandemic. As of September 2020, the number of COVID-19 cases and new domestic infections in Thailand remains relatively low. Thailand's ability to contain the spread of COVID-19 thus far has been attributed to factors such as the country's past experiences with similar epidemics, the citizen's readiness to wear face masks, a culture of hygiene, and successful public health campaigns [4].

Thailand is often considered as a good practice to reduce the infection rate at an early stage [4]. However, there are little holistic analysis on this. Therefore, this paper aims to provide a short yet comprehensive overview of the responses to COVID-19 in Thailand and to examine the extent to which the measures taken are in line with the guiding principles of Sendai Framework for Disaster Risk Reduction 2015–2030 of the United Nations Office for Disaster Risk Reduction (UNDRR). The Sendai Framework is a landmark document in the domain of disaster risk reduction, which also addresses the challenges brought about by COVID-19, as the framework categorizes epidemics and pandemics as a biological hazard. The case study presented by this paper can be used for comparative analysis of national responses to COVID-19. The findings of this paper bring to light how Thailand can become more resilient to public health crises such as COVID-19 and can therefore be useful not only for academics but also for policymakers and civil society actors. Here, resilience is to be understood as "the ability of a system, community or society exposed to hazards to resist, absorb, accommodate to and recover from the effects of a hazard in a timely and efficient manner, including through the preservation and restoration of its essential basic structures and functions." [5]. It is argued that the resilience of the country and communities depend on the inherent governance and stakeholder participation, which is linked to four priorities of Sendai Framework.

2. Methods

This paper examines how Thailand responded to the COVID-19 pandemic, specifically focusing on the public health and legislative measures. The core of the current analysis lies on the national government policy analysis, supplemented by document reviews and analysis. Information about the measures taken is derived mainly a thorough review of daily governmental announcements about COVID-19, which happen via national television as well as through governmental websites and social media accounts, most notably the website of the Department of Disease Control of the Ministry of Public Health. News articles reporting about COVID-19 were selected from Google searches made with relevant keywords and then analyzed to establish a better understanding of how COVID-19 and the response measures have impacted the public. While governmental announcements and decrees are rarely translated from Thai, English-language articles published by were prioritized to make the cited sources accessible to non-Thai speakers.

The relevant plans and measures taken are critically analyzed through the lens of the Sendai Framework for Disaster Risk Reduction to highlight the robustness and shortcomings of Thailand's approach with regards to resilience. The analysis is mainly based on: (1) public health capacity and response, and (2) legislative measures. Public health capacities are mainly evaluated based on three issues: (1) health resources in the country,

(2) COVID-19 testing, and (3) community based public health initiatives. On the other hand, the legislative measures are analyzed based on Emergency Decree and Disaster Mitigation and Prevention Act. Both the analyses then linked to the four priority areas of Sendai Framework. Sendai Framework.

Sendai framework has four priority areas: (1) understanding disaster risks, (2) strengthen disaster risk governance, (3) investing in disaster risk reduction, and (4) enhancing disaster preparedness for effective response. The Sendai Framework reinforces the scope of disaster risk management by expanding beyond natural hazards to include biological hazards such as epidemic- and pandemic diseases. The Sendai Framework also places strong emphasis on the need to build resilient health systems through the integration of disaster risk management into the provision of health care at all levels and, in particular, "to enhance cooperation between health authorities and other relevant stakeholders to strengthen country capacity for disaster risk management for health."

3. Results

3.1. Public Health Capacity and Response

3.1.1. Health Resources in Thailand

While 80% of COVID-19 patients are able to recover without medical treatments [6], many patients develop severe symptoms and may require hospitalization and even intensive care. Patients with lung damage may require the use of non-invasive mechanical ventilators, depending on the severity of the symptoms, to help them breathe. Additionally, hospitals need to have negative pressure isolation rooms and a sufficient amount of personal protective equipment (PPE) to help prevent the spread of the virus within the hospital. Health resources, which refers to "the means available for the operation of health systems, including human resources, facilities, equipment and supplies, financial funds, and knowledge" [7] are therefore critical to the mitigation of the impacts of COVID-19 and prevention of loss of life.

Hospitals in Thailand are divided into three categories, namely (1) public hospitals operated by the Ministry of Public Health, (2) public hospitals operated by other entities (e.g., Medical Service Department of Bangkok Metropolitan Administration, Ministry of Education, Royal Thai Army, Thai Red Cross) and (3) private hospitals. The majority of hospitals in Thailand are public hospitals operated by the Ministry of Public Health, which can be further categorized into central, regional, and community hospitals. According to the Strategy and Planning Division of the Thai Ministry of Health [8], in 2019 there was a total of 158,026 hospital beds at 1370 hospitals across Thailand. This means that Thailand has 2.2 hospital beds per 1000 citizens. To put things into perspective the OECD data shows that the average number of beds per 1000 citizens of its member countries in 2017 was 4.7, with the highest rates being 13.1 and 12.3 beds per 1000 people in Japan and South Korea, respectively [9].

Since 2002, Thailand offers a comprehensive insurance scheme to all its citizens. This scheme was first introduced in 2001 and originally required beneficiaries to contribute a co-payment of 30 baht for medical treatments. The co-pay has since been abolished, and the scheme is now colloquially known as the "gold card" scheme. Universal healthcare is also made available via a civil servant insurance scheme and a private sector employee social security scheme. Under these schemes, 99.5% of the population of Thailand is eligible for healthcare coverage [10].

3.1.2. COVID-19 Testing and Treatment

On 21 March 2020, Thai citizens were told by the government that they should call the hotline of the Department of Disease Control or to go to the hospital that they are registered at to get tested for COVID-19 if they fall under the following criteria:

1. Having had a fever of over 37.5 °C with one or more respiratory symptoms (cough, runny nose, sore throat, rapid breathing or breathing difficulties), in addition to one or more risk factors14 days before the onset of the symptoms.
   (a) Travelling to or from a country or residing in an area with an ongoing COVID-19 outbreak;
   (b) Professional who have had close contact with tourists from areas with ongoing COVID-19 outbreaks;
   (c) Having had close contact or high-risk exposure to confirmed COVID-19 patients in accordance with surveillance and investigation guidelines;
   (d) Being a medical or public health personnel who has come into contact with a suspected or confirmed COVID-19 patient or to the bodily fluids of a suspected or confirmed COVID-19 patient without appropriate protective equipment;
   (e) Having been to a densely populated area at the same time as a confirmed COVID-19 patient, in accordance with the announcement of the provincial infectious disease committee.
2. Pneumonia patients who:
   (a) Has had of close contact with a confirmed COVID-19 patient;
   (b) Is a medical personnel;
   (c) Is experiencing pneumonia without an identifiable cause and who is not recovering within 48–72 h of treatment;
   (d) Exhibits pneumonia characteristics that are consistent with COVID-19.
3. Persons who are suspected to be part of an infection cluster, which is defined as:
   (a) Three or more medical personnel of the same department testing positive for COVID-19 within one week. For smaller establishments e.g., clinics, the criteria used is 3 or more personnel of the establishment;
   (b) For those who are not healthcare workers, five or more infections from the same place within one week with an epidemiological link [11].

Those who fall under any of these criteria can get tested for COVID-19 for free. If they have been infected with the virus, they will also receive free treatments. Those who do not fall under any of these criteria may nevertheless get tested for COVID-19 but at their own cost. In public hospitals, COVID-19 tests cost 2500 to 9900 THB. In private hospitals, the test costs 5000 to 10,500 THB. Under the universal healthcare scheme, confirmed COVID-19 patients will receive free medical treatments according to the procedures of the Ministry of Public Health. Table 1 shows the country data of COVID-19 infection.

Table 1. COVID-19 data in Thailand as 27th December 2020.

	Number of People
Cumulative cases	6123
Recovered patients	4161
Deaths	60

Data from the Department of Disease Control, Ministry of Health, Government of Thailand.

3.1.3. Community-Level Public Health Initiatives

In Thailand, the village health volunteers (VHVs) scheme is central to the National Primary Health Care program's effort to be able to reach more people at a low cost [12]. VHVs are individuals chosen by villagers to receive basic medical training according to the requirements of the Ministry of Public Health in order to help inform and support public health in their community. The initiative started in 1978, and there are now over a million VHVs all over the country. Tasked with the goal of controlling and preventing the spread of diseases, VHVs were influential in mitigating the impacts of the SARS and avian flu outbreaks in Thailand [13]. During the COVID-19 pandemic, VHVs played an important role in preventing the spread of the diseases by going door to door to inform people about COVID-19 symptoms and to screen the residents' COVID-19 risks by asking them about their travel history and symptoms. They also reported COVID-19 related data to the provincial health office. The VHVs enabled the public to be informed about COVID-19 as well as collected data that are essential for public health decision-making. This is essential to effective COVID-19 response, as demonstrated by a study on how of how China responded to the epidemic [14].

3.2. Legislative Measures

On 25 March 2020, the Thai government announced a state of emergency. This allows them to operate according to the Emergency Decree on Public Administration in Emergency Situation, B.E. 2548 (2005) which grants the Prime Minister more decision-making power as well as the ability to impose certain restrictions. The most important clause of the Emergency Decree is Section 9, which explicitly grants the Prime Minister the power to issue regulations to prohibit or restrict personal movements, assemblies, fear-mongering or misleading communications, usage of routes and buildings, as well as to implement evacuations or preventing entry to designated areas. These measures allow the Thai Government to implement restrictions that go beyond what is permitted under the Disaster Prevention and Mitigation Act B.E. 2550, which includes the power to quarantine individuals, to inspect residences, and to restrict the use of routes and vehicles. As of September 2020, the Emergency decree has been extended 5 times and remains active. This has raised some criticisms from those who believe that it is unnecessary for the government to maintain a state of emergency due to a very low rate of domestic COVID-19 infections in Thailand.

One of the first actions of the Prime Minister was the creation of the Center for COVID-19 Situation Administration (CCSA) and an executive committee comprising of ministers and heads of departments that will report directly to the Office of the Prime Minister. They are tasked with implementing policies according to the Communicable Diseases Act B.E. 2558, Disaster Prevention and Mitigation Act B.E. 2550, and the State Administration Act B.E. 2534 (Office of the Prime Minister, 2020). The Thai government has issued numerous announcements of different restrictions such as the closure of certain places and halting some services in order to prevent the spread of COVID-19. Each province also had their own set of restrictions that are issued by the provincial governors. The provincial-level restrictions follow the provisions of the Communicable Diseases Act B.E. 2558 [15].

3.3. Analyzing Thailand's Response to COVID-19 through Sendai Framework

Adopted by UN member states in 2015, the Sendai Framework for Disaster Risk Reduction (2015–2030) is a document that provides guidance on disaster risk reduction. The Thai Department of Disaster Prevention and Mitigation includes epidemics as one of the disasters that they handle, which is appropriate considering the definition of a disaster being "A serious disruption of the functioning of a community or a society at any scale due to hazardous events interacting with conditions of exposure, vulnerability and capacity, leading to one or more of the following: human, material, economic and environmental losses and impacts" [16].

Thailand's response to the COVID-19 pandemic can be analyzed through the four priorities of the Sendai Framework, which serve as guiding principles for robust and comprehensive disaster risk reduction. Effective and relevant risk management of biological hazards changes with the advancement of science, clinical medicine and public health practices and policy. The latest technical guidelines and research findings to support planning may be found in WHO's Health-Emergency Disaster Risk Management (Health-EDRM). Although the Sendai Framework strongly focuses on biological hazards and its risk mitigation approaches, there is hardly any country analysis on this.

3.3.1. Understanding Disaster Risk

The Sendai Framework highlights how policies and actions should be based on a thorough understanding of disaster risk. The Thai Disaster Prevention and Mitigation Act B.E. 2550 recognizes epidemics as disasters, so the Department of Disaster Prevention and Mitigation has been involved in the handling of the COVID-19 pandemic. Thailand's understanding of COVID-19′s various risks is supported by how the country's previous experiences with respiratory diseases outbreaks such as SARS, avian flu, and MERS. The Ministry of Public Health was at the forefront of the country's COVID-19 related decision-making and planning. The Ministry oversaw measures such as helping medical facilities around the country prepare for COVID-19 testing and treatment as well as involving VHVs to help the authorities to have a better understanding of the spread of COVID-19, which allows science-based decisions to be made. The Thai government also introduced the contact tracing applications that provide information to the Department of Disease control. However, the applications have been criticized for privacy issues [17].

On the other hand, socioeconomic risks of the pandemic seemed to have been overlooked, as suggested by the government's limited capacity for providing assistance to vulnerable populations. The Thai government has also been criticized for its insistence to maintain the emergency situation and closed borders despite having had zero cases of domestic infections for over 100 days up until 4 September 2020. Indeed, it is a challenge for governments to determine the optimal stringency of their pandemic measures that would allow them to effectively contain the outbreak without inflicting too much economic damage. Ashraf (2020a) [18] found that "announcements regarding the implementation of social distancing measures by governments have dual, a direct negative and an indirect positive, effect on stock market returns." While the announcements of social distancing measures "result in negative stock market returns due to their expected adverse impact on economic activity", they also "lead to positive market returns through the channel of reduction in COVID-19 confirmed cases." As a country that relies heavily on tourism and from exporting goods, Thailand suffered severe economic impacts due to COVID-19. The Asian Development Bank (ADB) estimated a contraction of −8.0% in the Thai GDP, and that Thai exports of goods and services contracted by 17.6% (in US dollars terms) [19]. Many businesses suffered directly and indirectly from government measures such as border closure and COVID-19 restrictions on restaurants and other services that were introduced during the first and second wave of infections in Thailand. As a result, many people in Thailand lost their income completely or partially. This was especially devastating for day laborer, informal workers, and the urban poor, who also struggled to receive government assistance for reasons such as the lack of access to digital services or difficulties in fulfilling bureaucratic requirements.

For biological hazards, a comprehensive multi-hazard and multi-sectoral National Risk Assessment (NRA) needs to be conducted. The assessment should include exposure, vulnerability, and capacity analyses as part of an integrated policy approach. The cascading effect of different disasters should also be considered, keeping in mind a systemic risk approach. A health risk assessment needs to be an integral component of the risk assessment whenever risk informed public health management is required. For responding to an epidemic or pandemic, an early stage risk assessment and scenario planning incorporating the impacts on different sectors would be required. Real time location-based risk maps should be maintained for enhanced coordination among the different actors. Data sharing and big data analysis also becomes crucial for this step.

Capacity and systems development for integrated risk assessment at the national to a local level is important. Disciplinary divergence (wherever possible) and multi-disciplinary collaboration are key to producing an integrated risk assessment. Higher education/research capacities need to be strengthened, and trans-disciplinary to multi-disciplinary innovative research should be promoted.

3.3.2. Strengthening Disaster Risk Governance to Manage Disaster Risk

For disasters to be managed effectively and efficiently, there should be "Clear vision, plans, competence, guidance and coordination within and across sectors, as well as participation of relevant stakeholders" [19]. Thailand's COVID-19 response has been guided by the Emergency Situation Decree and was largely led by the Prime Minister via the Center for COVID-19 Situation Administration. However, there is a degree of decentralization as provincial governors were responsible for introducing restrictions against the spread of COVID-19. On 25 January 2020, the Department of Disaster Prevention and Mitigation, which falls under the Ministry of Interior, issued an announcement to all provincial governors to prepare and plan for the spread of COVID-19 in their jurisdiction. The announcement urged the governors to be alert, to make COVID-19 containment plans as well as necessary preparations, and to report any confirmed cases to the Department. On 20 March, the "Integrated Plan for Multilateral Cooperation for Safety and Mitigation of COVID-19" was published. This plan is comprehensive and assigns keys responsibilities to the relevant ministries and departments. The provincial governors were also told to align the local COVID-19 strategies with this plan.

It is important to identify synergies between the health emergency and disaster risk management regulations, and where applicable, review laws specific to epidemics and pandemics to determine implications for disaster risk management. The revision of regulations or legislation related to disaster risk management should be considered to enhance the scope to include biological hazards. The relevant policies and plans also need to be customized.

Science-based, data-centric decision-making is considered important for early identification of hotspots, to provide policy makers with the appropriate advice, and to address collateral hazards. Inclusion of a multi-disciplinary scientific community in national platforms for DRR is important to ensure different perspectives are brought in for decision-making. This will aid in the development of an integrated risk assessment, scenario planning, forecasts of the spread of the epidemic, etc.

3.3.3. Investing in Disaster Risk Reduction for Resilience

Effective disaster risk reduction requires investments for enhancing the resilience of people, their assets, and their environment. Investments include financial and non-financial resources, which can be used for both structural and non-structural measures. In the context of COVID-19, a country's response is heavily influenced by the investments that have been made both before and during the pandemic not only in public health but also in other domains such as social welfare. Thailand's experience with COVID-19 highlights the importance of the country's past investments into the national public health system and to the VHV scheme. The experience also showed how the lack of social safety nets undermines Thailand's resilience, especially in times of crisis. The government initially struggled to provide the 5000 THB relief to low-income citizens whose livelihood were affected by the pandemic, which contributed to a spike in financially driven suicide attempts in May [20].

As a response to the COVID-19 pandemic, the Thai government unlocked a 2.2 trillion THB (USD 61 billion) relief package that is primarily aimed at providing financial assistance to individuals and SMEs [21,22]. This includes providing financial aid to vulnerable populations, reducing the cost of living by subsidizing natural gas costs and introducing tax reduction, exemption, and delays. However, there is a lack of clarity in how this budget will be spent exactly and there is currently no mention of using it for investments for disaster risk reduction. Through their case study of Japan where governmental financial stimulus was also directed to resilience planning and development, DeWit et al. [23] highlight the importance of a holistic approach to disaster risk reduction by emphasizing that responses to the COVID-19 pandemic should also promote resilience and sustainability in a wider sense.

Investment varies based on the socioeconomic nature of the country. In recent analysis of more than 80 countries socio economic data, Ashraf (2020b) [24] concluded that a stringent lockdown at initial stage, a better social distancing policy and generous economic/fiscal boosting helps the middle to lower income countries to address the socioeconomic issues in pandemic, as well as reduce the number of deaths. In Thailand, the tourism sector plays an important role, which is hardly hit by the pandemic. Farzanegan et al., (2020) [25] concluded that international tourism is highly impacted, which is the same case as Thailand. Thus, investing in boosting domestic travel and tourism to cope with the immediate impact becomes very important. This is also the case of "Go To Travel" campaign in Japan.

Epidemics and pandemics affect wide sectors of society and put both lives and livelihoods at risk, which also impedes development. Fiscal boosting is an important tool for enhancing not only economic recovery, but through a proper social protection measures, can also enhance social safety nets. Existing tools and methods for registering the most vulnerable groups should be adapted to be quickly adjusted and used to identify priority groups for support.

Keeping with a whole-of-society approach, public-private partnerships and business-to-business cooperation are important elements to ensure the continuity of supply chains. This assumes higher significance in the context of supporting small and medium enterprises (SMEs), including those which operate in the informal sector and hence are often left out of social and economic assistance packages.

3.3.4. Enhancing Disaster Preparedness for Effective Response and to "Build Back Better" in Recovery, Rehabilitation, and Reconstruction

According to the Sendai Framework, "Disasters have demonstrated that the recovery, rehabilitation, and reconstruction phase, which needs to be prepared ahead of a disaster, is a critical opportunity to "Build Back Better", including through integrating disaster risk reduction into development measures, making nations and communities resilient to disasters" [18]. It is unclear whether the Thai government has started planning for post-pandemic actions, and no recovery plan or business continuity plan has been announced as of September 2020. There has also been no announcements business continuity planning. As such, there is currently no known plans for the Thai government to use the COVID-19 budget for sustainable development or for enhancing resilience against public health or environmental hazards.

Early warning is key to responding to any type of hazard, and biological hazards are no exception. A proper early warning system for biological hazards can be developed only when there is a robust public health system in place, which detects any biological hazards before outbreaks occur. This issue needs to be incorporated in development planning as well. Like with natural hazards, a key to early warning is end-to-end communication, where last mile communication is crucial. It is also important that the biological hazard early warning system be integrated into the existing multi-hazard early warning system, which usually focus on natural hazards.

Since epidemics and pandemics are often long lasting, proper business continuity planning for core impacted sectors/ministries is critical. These plans should be developed in advance or at an early stage of the event. Moreover, emergency operation centers should be optimized. Where possible, protocols should be adapted based on lessons from previous disasters while integrating the particularities of the biohazard. Crisis leadership in both the public and private sectors are important. As the situation changes over time, it will be important have an adaptive strategy that can synchronize with the scenario planning.

While most epidemic and pandemic responses focus on impact management, it is equally important to look at root causes and enhance impact reduction. Risk reduction approaches need to be the core of the response mechanism, as well preventative risk reduction in non-emergency decision-making and investment. Volunteers, civil society organizations, and structures at the decentralized level that are working directly on awareness raising and response should be trained regularly to work under the conditions of epidemics and pandemics to ensure their safety and continuity of operations. Lessons from past biological hazards are needed to be taken into account and capacity might need to be strengthened to introduce new institutional arrangements to transform the risk profile.

4. Conclusions

While Thailand's response to COVID-19 has been quite effective in limiting the spread of the disease, it falls short at being able to address the multiple dimensions of the crisis, such as the economic and social impacts. The Sendai Framework for Disaster Reduction helps highlight how Thailand's approach to COVID-19 does not comprehensively address the issue of resilience—there are limited considerations given to building resilience against climate change or other epidemics. Thailand's success in containing COVID-19 can be partly attributed to its public health system and to VHVs. VHVs, in turn, benefitted from collaboration with local community leaders and civil society organizations. This suggests that one opportunity for enhancing resilience in Thailand is to strive for more multilevel governance that engages with various stakeholders and to support grassroots and community-level networks.

It can be noted that the Thai approach to COVID-19 response is not very holistic as little consideration has been given to enhancing the country's resilience to such pandemics as well as to 'build back better' in a more environmentally or socially sustainable way. The economic cost of border and business closures and strict restrictions in Thailand has been immense. Businesses in the service and tourism sector were hit the hardest. They are also the sector that employs a large portion of the workforce, who are now financially insecure: Before the COVID-19 pandemic, tourism accounts for 22% of the Thai GDP, and in 2018, one in six jobs in Thailand were in the tourism sector [26]. This sector is highly impacted, along with its link to other formal and informal sectors. The scale of the economic impact of the pandemic as a result of Thailand's reliance on its tourism sector also highlights the importance of a diversified economy for more resilience. The government's initial failure to effectively assist low-income and vulnerable populations during the pandemic suggests that they are not included or appropriately prioritized by the government's COVID-19 risk assessment and planning. However, this seems to have been improved overtime with better governance and decision-making. Although Thailand has been relatively successful at mitigating the public health risks of the COVID-19 pandemic, the impact of the subsequent economic risks and the lack of consideration for building resilience in a broader sense may lead to further vulnerability in the future.

The recovery from past outbreaks, epidemics, and pandemics have shown that an overburdening of the ecosystem services occurred due to increased production for economic gain to make up for losses. Ecosystem services have a more or less constant regeneration cycle, which is disrupted by this sudden surge in demand, thus tipping the threshold of regeneration. Issues of overfishing and clearing of forests could disturb life under water and on land. The increase in production and travel in the aftermath of the health emergency may also increase air and water pollution levels, which might impact the health and wellbeing of people with pre-existing respiratory comorbidities. Further, changes in climatic conditions (temperature, humidity, precipitation, sea level sensitivity) will act as a risk multiplier to other non-communicable and infectious diseases and biological hazards, based on their seasonality and return period. For instance, a decrease in public utility services, like solid waste collection and cleaning of drains may lead to an increase in breading of mosquitoes putting countries identified as dengue hotspots at a higher risk of an outbreak.

The COVID-19 pandemic recovery is a chance to recover better while leaving no one behind. An inclusive long-term recovery plan for the various impacted countries needs to take a holistic approach to address existing gaps and work towards a sustainable society. A biological hazard like the COVID-10 pandemic is an opportunity to strengthen Partnerships under Goal 17 of Sustainable Development Goals (SDGs) to develop warning mechanisms and to reduce gaps in data sharing and accuracy for effective evidence-based policy and decision-making. The role of science and technology and multi-stakeholder partnerships are of importance in such a case. Better global partnerships and effective risk governance need to be brought into the core of preparedness and response for future health emergencies. Furthering the Health Emergency Disaster Risk Management (HEDRM) Framework may support a coordinated response across various linked sectors rather than straining one particular sector.

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References

1. OECD. Coronavirus (COVID-19) (2020): Joint Actions to Win the War. Available online: https://www.oecd.org/about/secretary-general/Coronavirus-COVID-19-Joint-actions-to-win-the-war.pdf (accessed on 6 December 2020).
2. World Health Organization. WHO Coronavirus Disease (COVID-19) Dashboard (2020). Available online: https://covid19.who.int/table (accessed on 6 December 2020).
3. Boonbandit, T. Army Orders Probe into Super-Spreader Boxing Match. Available online: https://www.khaosodenglish.com/news/crimecourtscalamity/2020/03/26/army-orders-probe-in-super-spreader-boxing-match/ (accessed on 6 December 2020).
4. Bello, W. How Thailand Contained COVID-19—Foreign Policy In Focus. Available online: fpif.org/how-thailand-contained-covid-19/ (accessed on 6 December 2020).
5. UNDRR. Resilience. Available online: https://www.undrr.org/terminology/resilience (accessed on 6 December 2020).
6. World Health Organization. Media Statement: Knowing the Risks for COVID-19. Available online: https://www.who.int/indonesia/news/detail/08-03-2020-knowing-the-risk-for-covid-19 (accessed on 6 December 2020).
7. World Health Organization. Glossary. In *European Observatory on Health Systems and Policies*; WHO: Geneva, Switzerland, 2009.
8. Strategy and Planning Division of the Thai Ministry of Health. Health Resources Report B.E. 2562. Available online: https://bps.moph.go.th/new_bps/sites/default/files/Report%20Health%20Resource%202019.pdf (accessed on 6 December 2020).
9. OECD. Health Equipment—Hospital Beds—OECD Data. Available online: https://data.oecd.org/healtheqt/hospital-beds.htm (accessed on 6 December 2020).
10. The World Bank. Thailand: Sustaining Health Protection for All. Available online: https://www.worldbank.org/en/news/feature/2012/08/20/thailand-sustaining-health-protection-for-all (accessed on 6 December 2020).
11. Ministry of Public Health. ความคุ้มครองประชาชนสิทธิบัตรทอง กรณีมีอาการสงสัยป่วย “โรคโควิด-19”. In Thai. Available online: http://healthydee.moph.go.th/view_article.php?id=739 (accessed on 6 December 2020).
12. Bhutta, Z.A.; Lassi, Z.S.; Pariyo, G.; Huicho, L. Global Experience of Community Health Workers for Delivery of Health Related Millennium Development Goals: A Systematic Review, Country Case Studies, and Recommendations for Integration into National Health Systems. Available online: https://www.who.int/workforcealliance/knowledge/publications/alliance/Global_CHW_web.pdf (accessed on 6 December 2020).
13. Fuller, T. Small fixes: Volunteers Forge Better Care in Thailand’s Villages—The New York Times. Available online: https://www.nytimes.com/2011/09/27/health/27volunteer.html (accessed on 6 December 2020).
14. Hua, J.; Shaw, R. Corona Virus (COVID-19) “Infodemic” and Emerging Issues through a Data Lens: The Case of China. *Int. J. Environ. Res. Public Health* **2020**, *17*, 2309, doi:10.3390/ijerph17072309.

15. Royal Thai Government Gazette. Available online: http://www.ratchakitcha.soc.go.th/DATA/PDF/2563/E/104_3/1.PDF (accessed on 6 December 2020).
16. UNDRR. Disaster Terminology. Available online: www.undrr.org/terminology/disaster (accessed on 6 December 2020).
17. Hicks, W. Thai Covid-19 Apps Judged Invasive. Available online: www.bangkokpost.com/business/1954287/thai-covid-19-apps-judged-invasive (accessed on 6 December 2020).
18. Ashraf, B.N. Economic impact of government interventions during the COVID-19 pandemic: International evidence from financial markets. *J. Behav. Exp. Financ.* **2020**, *27*, 100371, doi:10.1016/j.jbef.2020.100371.
19. Asian Development Bank. Asian Development Outlook 2020 Update: Wellness in Worrying Times. Available online: https://www.adb.org/sites/default/files/publication/635666/ado2020-update.pdf (accessed on 6 December 2020).
20. UNDRR. Sendai Framework for Disaster Risk Reduction 2015–2030. Available online: https://www.undrr.org/publication/sendai-framework-disaster-risk-reduction-2015-2030 (accessed on 6 December 2020).
21. Salvá, A. Thailand: The Coronavirus Suicides. Available online: https://thediplomat.com/2020/05/thailand-the-coronavirus-suicides/ (accessed on 6 December 2020).
22. Janssen, P. Covid-19 Drives Thailand Deeper into Poverty. Available online: http://www.asiatimes.com/2020/06/covid-19-drives-thailand-deeper-into-poverty/ (accessed on 6 December 2020).
23. DeWit, A.; Shaw, R.; Djalante, R. An Integrated Approach to Sustainable Development, National Resilience, and COVID-19 Responses: The Case of Japan. *Int. J. Disaster Risk Reduct*. **2020**, *51*, 101808 doi:10.1016/j.ijdrr.2020.101808.
24. Ashraf, B.N. Socioeconomic conditions, government interventions and health outcome during COVID-19. *Covid Econ.* **2020**, *37*, 141–162.
25. Farzanegan, R.; Gholipou, H.; Feizi, M.; Nunkoo, R.; Eslam, A. International tourism and outbreak of Coronavirus (COVID-19): A cross-country analysis. *J. Travel Res*. **2020**, 1–6, doi:10.1177/0047287520931593.
26. Fitch Solutions. Virus Imperils Thai Economy—Knok-on Impact from Sharp Tourism Slowdown Could Be Broad and Last for Many Months. Available online: https://www.bangkokpost.com/business/1850904/virus-imperils-thai-economy (accessed on 6 December 2020).

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Article

COVID-19 Impact on SDGs and the Fiscal Measures: Case of Indonesia

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Abstract: The implications of the ongoing COVID-19 pandemic have stretched far beyond human health and wellbeing, causing serious setbacks for the achievement of the Sustainable Development Goals (SDGs). Although governments worldwide have implemented different fiscal stimulus measures to mitigate the implications of COVID-19, it is important to develop a precise understanding of their focus areas to ensure if the progress of SDGs is on track. For a specific case of Indonesia, this study establishes a thorough understanding of the COVID-19 implications on SDGs, and its fiscal stimulus package through a literature review and semi-formal interviews with the core stakeholders in Indonesia. The study results highlighted that COVID-19 has varyingly affected the progress of all SDGs in Indonesia. Amongst the four pillars of sustainable development in Indonesia, the SDGs on the social and economic development pillars are stated to be the most impacted. As for the fiscal stimulus, it is perceived that it can help maintain the SDGs' attainment progress to a certain extent, although there are several concerns on its implementation. Deriving lessons from the conducted research, the study puts forward key suggestions for the effective implementation of SDGs in the post-COVID-19 era.

Keywords: COVID-19; sustainable development goals; fiscal stimulus; Indonesia

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1. Introduction

The first cases of coronavirus disease 2019 (COVID-19), a respiratory illness caused by the novel form of coronavirus called severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), were reported in China towards the end of 2019. It was later declared a pandemic by the World Health Organization (WHO) on 11 March 2020, after the virus spread to more than 110 countries and there were 118,000 confirmed cases worldwide [1]. By 5 March 2021, the global confirmed cases for COVID-19 had surpassed the staggering figure of 114 million, with over 2.5 million deaths [2].

Despite the fact that the COVID-19 pandemic is still unfolding, countries all over the world have distinctly executed a range of countermeasures to control and manage the spread of the virus, including the closure of educational, commercial, sports, and religious institutions [3]. In that manner, the impact of the COVID-19 pandemic has extended far beyond the global health sector, affecting the social and economic sectors as well. Border controls have been strengthened, as have lockdowns and travel bans, resulting in widespread economic closures and job losses. According to the WHO [4], over 10 million people are at risk of falling into severe poverty, and malnutrition is predicted to increase by up to 130 million people. Furthermore, the COVID-19 pandemic has also posed major challenges for achieving sustainable development in the context of increasing food insecurity, hunger, and unemployment.

Initially, 2020 was supposed to be the marking point of the Decade of Action to keep track on the 2030 Sustainable Development Agenda, and the 17 defined Sustainable Development Goals (SDGs) [5]. Having been already behind, the progress of SDG attainment worldwide has been further pushed back due to the emergency of the COVID-19 pandemic. Specifically, in the developing nations of South-East Asia—although all the member states of the Association of South East Asian Nations (ASEAN) have geared towards achieving SDGs by 2030—none of the 17 SDGs have been met [6]. It is projected that the COVID-19 pandemic will further delay the progress of SDGs in the region [7].

Indonesia—like all other nations—is also struggling through the pandemic's emergency consequences. Early in March 2020, the first confirmed case in Indonesia was recorded, and COVID-19 was then declared a national non-natural disaster by the Indonesian government on 13 April 2020 [8]. By 5 March 2021, there were more than 1.36 million confirmed cases, and 26,897 deaths [9]. The Indonesian government's numerous countermeasures, such as large-scale social restriction, physical distancing, massive rapid testing, and work and study from home policies, have all resulted in considerable economic downturn [10]. To this extent, COVID-19's impacts have hampered Indonesia's progress toward the SDGs [11,12].

Referring to the Sustainable Development Report in 2020 [13], some SDGs are on track and moderately improving, while other SDGs are posing major challenges and showing a stagnant progress pattern. In the backdrop of COVID-19, Indonesia faces greater challenges in achieving the SDGs by 2030, as the economic downturn has affected households, Small and Medium Enterprises (SMEs), corporations, and the financial sector [14]. As a result, the Indonesian government implemented the fiscal stimulus to offset the multisector effects of the COVID-19 pandemic [11,14].

The fiscal stimulus and/or state budget instruments are stated to be driving the economic improvements in handling the COVID-19 pandemic and the national economic recovery program [15]. Although Indonesia's economy grew in the third quarter (Q3) of 2020 [16], there is no clear information as to what extent the fiscal stimulus is intended for achieving SDGs during the COVID-19 outbreak, although they have been defined as critical [17]. As such, the implications of COVID-19 for SDGs' progress in Indonesia are yet to be understood, let alone the role of fiscal measures towards the SDGs' implementation.

While extensive research studies have been conducted so far to study the implications of the COVID-19 pandemic, there have been very few empirical studies seeking to understand their consequences on the progress of SDGs and the relative role of fiscal stimulus measures. Furthermore, since COVID-19 economic recovery packages must be designed to not only mitigate the pandemic's short-term repercussions, but also to "build back better" towards a more sustainable and resilient future [18,19], it becomes more imperative to understand how the fiscal stimulus initiatives have addressed the SDGs' attainment so far.

With an aim to bridge this gap, a qualitative research design (combination of a literature review and semi-formal interviews with key stakeholders) has been adopted in this study to methodically understand the impacts of COVID-19 on the progress of SDGs in Indonesia, as well as the role of fiscal measures for keeping SDGs on track. The three key objectives of this study are: (1) to establish a wider understanding about the impacts of the COVID-19 pandemic on the progress of SDGs in Indonesia; (2) to study the stakeholders' perception about the impact of the COVID-19 pandemic and the impact of stimulus measures towards the SDGs' progress; and (3) to suggest feasible directions for enhancing and strengthening the implementation of fiscal measures and SDGs in Indonesia. In doing so, the study addresses two key research questions: (1) How has the COVID-19 pandemic impacted the progress of SDGs? (2) What are the perceived direct and indirect impacts of fiscal policies in Indonesia towards the progress of SDGs' implementation?

For the study context, it is important to highlight that the "direct impacts" refer to the immediate impacts of the fiscal measures on the SDGs, while the "indirect impacts" refer to the relatively predictable effects of the stimulus on the SDGs that could arise later in time or in the cause-and-effect relationship chain.

Overall, this paper is divided into seven sections, the first of which is the Introduction (Section 1). Section 2 provides an overview of the current scientific literature on the SDGs, as well as the implications of the COVID-19 pandemic on SDGs worldwide, and the fiscal measures. The third section introduces the case study area of Indonesia, and Section 4 explains the research methods adopted in this study. In Section 5, the research findings and analysis are presented. The following section (Section 6) provides the relevant policy recommendations to resolve the immediate issues identified through this study. The final section (Section 7) outlines the key findings, contributions, and constraints of this research.

2. Literature Review

This section is mainly intended to establish a foundational view of the study's topic, based on the review of state-of-the-art scientific literature. It is divided into three sub-sections. The first sub-section provides an overview of the SDGs and their global progress. The second sub-section highlights the implications of the ongoing COVID-19 pandemic towards SDGs. The final sub-section discusses the fiscal stimulus programs implemented by governments around the world to overcome the repercussions of the COVID-19 pandemic.

2.1. Importance of the Sustainable Development Goals

On 25 September 2015, the 2030 Development Agenda (titled "Transforming our world: the 2030 Agenda for Sustainable Development") was adopted by 193 countries of the United Nations (UN) General Assembly, which serves as a framework for achieving peace and prosperity around the world. As the continuation of the Millennium Development Goals (MDGs), the 2030 Development Agenda outlines 17 SDGs and 169 associated targets, which frame the integrated plan of action in a global partnership for people, the planet, and prosperity [18,20,21]. The SDGs are primarily designed to provide policy guidance and to evaluate government performance in key areas that affect the people's and the planet's well-being [22].

Having been implemented for five years, the global progress on achieving the SDGs appears to be lagging behind in fulfilling the targets [5,23,24]. Barbier [25] stated that while some goals have made strides, they have come at the detriment of other goals. Poverty eradication, child and maternal health improvement, school and drop-out reduction, and women's participation are among the goals that have made some progress. However, the natural environment is still in grave danger, and inequality remains profound [5]. Now, the attainment of the 2030 Agenda for Sustainable Development faces unprecedented challenges due to the COVID-19 global pandemic [5,26].

2.2. Implications of COVID-19 on SDGs Worldwide

The progress of SDGs worldwide was already behind the target, and the COVID-19 pandemic brings tremendous challenges in realizing all the goals [23,27]. The pandemic has not only overshadowed the focus on SDGs, but it has also overturned the years of progress made so far [13,28]. COVID-19's effect on SDG 1 (No Poverty), SDG 2 (Zero Hunger), SDG 3 (Good Health and Wellbeing), SDG 4 (Quality Education), SDG 8 (Decent Work and Economic Growth), and SDG 17 (Partnership for the Goals) has been the subject of extensive discussion [14,23,27,29–32]. However, the pandemic's impacts on other SDGs have not received considerable coverage yet.

Based on the Sustainable Development Report in 2020 [13], the short-term impacts of COVID-19 on SDGs have been classified into three levels: High, Mixed or Moderate, and Unclear (refer to Figure 1). The "high level" category indicates that COVID-19 has had a major negative effect on the achievement of the SDGs, in which they become the key focus on SDG progress worldwide. The "mixed" or "mild" level comprise the SDGs that are experiencing moderately negative impacts through the pandemic, or both positive and negative impact on the progress of SDGs. The "unclear level" indicates that the impact of COVID-19 on the SDGs' progress is yet to be observed.

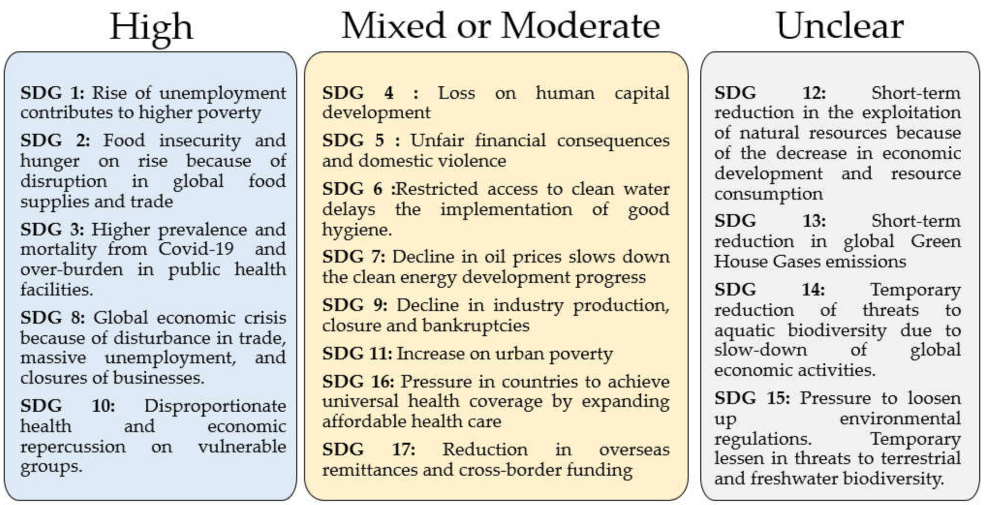

Figure 1. Short-term impacts of COVID-19 on the Sustainable Development Goals (SDGs) (Modified from Sachs [13]).

2.3. Fiscal Stimulus Measures around the World

Governments all over the world implemented fiscal stimulus initiatives to counteract multi-sector effects of the COVID-19 pandemic [33]. Herein, the fiscal policies primarily refer to the changes in government expenditures and taxation structures to affect a nation's economic conditions, and the fiscal stimulus specifically refers to the increase in government spending and tax cuts to stimulate public demand for goods and services [34]. Shortly after COVID-19 was declared a pandemic, the Governments of Japan, the United States (US), Canada, India, and South Africa all initiated massive fiscal stimulus programs, far exceeding the amount of stimulus implemented during the 2008 financial crisis. Likewise, Western European countries have already set aside up to four trillion USD for fiscal stimulus measures [35].

It is evident that the components of fiscal stimulus (to mitigate the impacts of COVID-19) differed from country to country. The ASEAN member states' fiscal stimulus packages were designed to assist people, households, and businesses in all sizes to survive the impacts of the pandemic and to improve the healthcare system [36]. Other nations such as Canada, Australia, and Japan used wage subsidies to distribute stimulus to workers and employers. France has increased its fiscal stimulus package, which includes funding for research and training. Germany, South Korea, and Japan have all initiated fiscal stimulus programs aimed at green growth and digital infrastructure [37].

The International Monetary Fund (IMF) [37] stressed that the fiscal stimulus (public investment) is essential to strengthen economic resilience, promote long-term economic development, and to support SDGs. As such, the stimulus packages with the primary objective of improving public health infrastructure have the ability to build resilience in addition to promoting the goal of SDG 3 (Good Health and Wellbeing) [38]. Furthermore, the social protection measures may contribute to addressing the pandemic's immediate issues while also building on long-term SDG commitments [39]. According to Zhang [40], the scope of social security policies has both direct and indirect effects in terms of preventing individuals from losing their jobs and properties, as well as indirect effects in terms of providing opportunities for the vulnerable to rise out of poverty, resulting in a more prosperous and resilient economy.

3. Case Study Area—Indonesia

Indonesia is one of the world's largest archipelagic countries with over 17,000 islands. It is located south of Malaysia and the Philippines, between the Asian and Australian continents, and between the Indian and Pacific oceans [41]. The central government, regional governments (34 provinces), regencies and towns (514 cities and regencies), districts (7071 districts), and villages (81,936 villages) make up Indonesia's governmental structure [42,43]. Regencies and cities as the sub-provincial level or local governments have greater responsibilities of management affairs and regional interests [44]. The current population of Indonesia is estimated to be 269 million [45]. More than half of the population reside on the island of Java, which has the highest rate of COVID-19 cases in the country (refer to Figure 2).

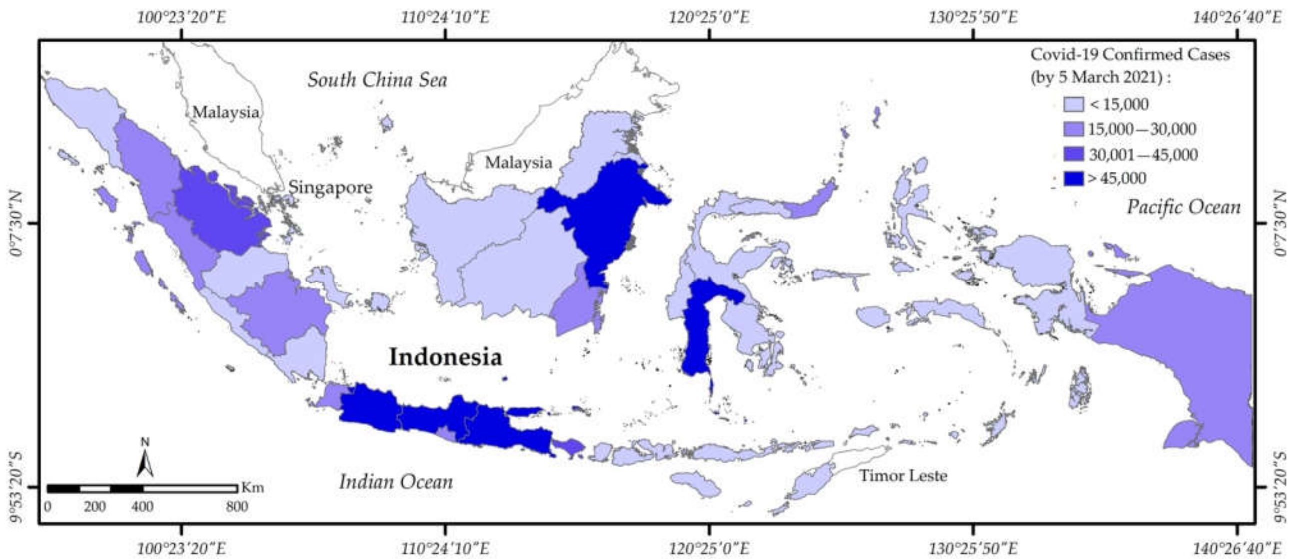

Figure 2. Indonesia's confirmed COVID-19 cases by province (Image source: author).

Like all nations worldwide, Indonesia has faced the widespread repercussions of COVID-19 not only in its public health but also in its economy. The COVID-19 pandemic has slowed the economic growth in Indonesia, as observed from the country's Gross Domestic Product (GDP) growth contracting in the first and second quarters of 2020 [10,46]. In 2021, the economy of Indonesia is expected to grow at a rate of 4.9–5.1% [47]. More notably, the economic recovery after COVID-19 in Indonesia is projected to be faster due to domestic demand-oriented economic growth that makes Indonesia less vulnerable to global economic downturns [47].

For the effective implementation of SDGs, Indonesia has taken considerable efforts to integrate the goals into its development strategies and policies, and to assure that these goals are implemented at the ground level. As a form of commitment to SDG implementation, the President of Indonesia signed the Presidential Regulation (Perpres) Number 59 Year 2017 (on July 4) on Achieving Sustainable Development Goals (SDGs) [48]. The decree regulates the structure of the National Coordination Committee, the engagement of representatives of the implementation team, and the task force of government agencies and non-government agencies, as well as the roles and responsibilities of the stakeholders. The regulation also assigned 17 goals and 169 indicators, aligning them with Indonesia's Long-Term National Development Plan (RPJPN) and Medium-Term National Development Plan (RPJMN). To support the SDGs' attainments, the Indonesian government has also developed a number of additional documents including the SDGs Road Map, National Action Plan (RAN) and Regional Action Plan (RAD), and SDGs metadata indicators which serve as guidelines for SDG implementation [48].

As the coordinator of SDG implementation in Indonesia, the Ministry of National Development Planning (BAPPENAS) has categorized the 17 SDGs into four development pillars [49], which are illustrated in Figure 3.

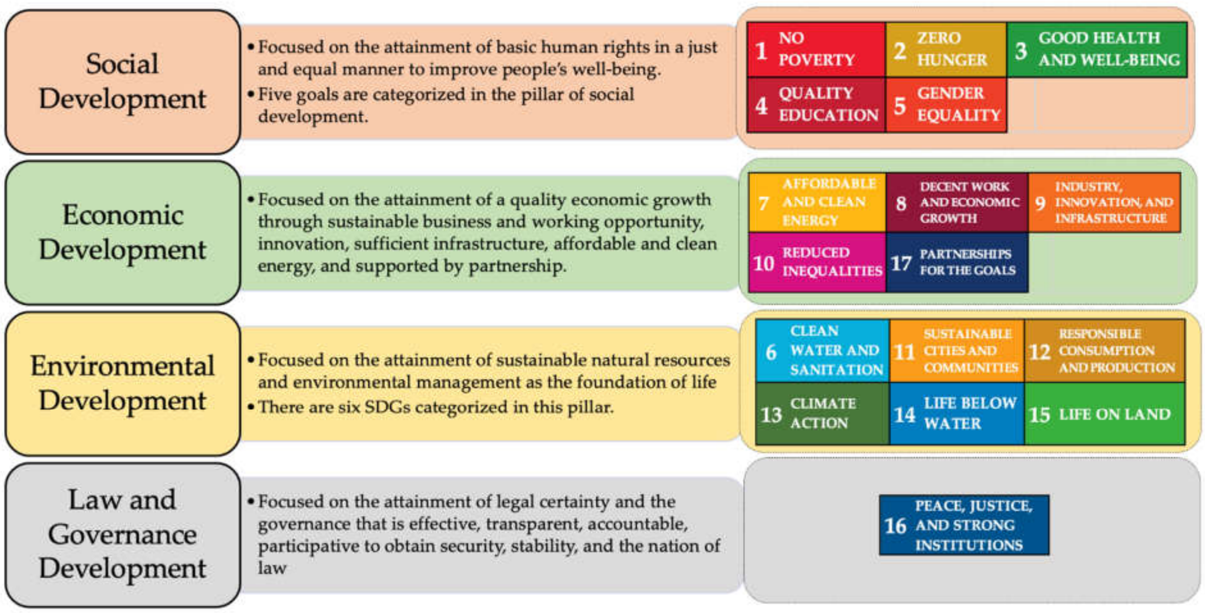

Figure 3. Four Sustainable Development Pillars in Indonesia (Modified from BAPPENAS [49]).

While the COVID-19 pandemic has caused significant disruptions to the progress of the 2030 Agenda, the deceleration is apparently concentrated in the social and economic development pillars of SDGs in Indonesia. The virus has taken a huge toll on public health services around the nation, and education has shifted from traditional classrooms to online platforms. As the poverty rate is expected to increase, there are also growing concerns about food insecurity. The pandemic is also likely to curtail the progress in achieving gender equality [11,49].

Under the cornerstone of economic development, the success of the SDGs has had significant ramifications. As explained earlier, Indonesia's economic growth has plummeted after the onset of COVID-19, and so has inequality. The advancement of clean and affordable energy has slipped down the priority list [32]. Reportedly, the environmental development pillar has experienced a positive impact of the pandemic, although it is more likely to be temporary [50]. Furthermore, the effects of COVID-19 on the law and governance development pillar have not yet been discussed widely.

Altogether, the COVID-19 pandemic has had a wide-ranging effect on the people as well as the economy in Indonesia. To overcome the economic meltdown, the Indonesian government has taken several efforts and established fiscal policy measures under the National Economic Recovery (PEN) program. The economic recovery package of Indonesia (PEN) comprised of around 4.2% of the nation's GDP, and its implementation is being performed in four phases [11], as illustrated in Figure 4. Phases 1 to 3 are currently ongoing and will continue until the COVID-19 pandemic is handled. The main focus of these phases is to implement fiscal stimulus measures that are delivered directly to a variety of target groups, including individuals, paramedics, corporations, SMEs, etc. The main aim is to boost Indonesia's economic growth out of recession. Phase 4 has not yet been implemented, and it will be executed only after the COVID-19 pandemic has been completely handled. The dedicated amounts of fiscal stimulus in Indonesia are shown in Table 1.

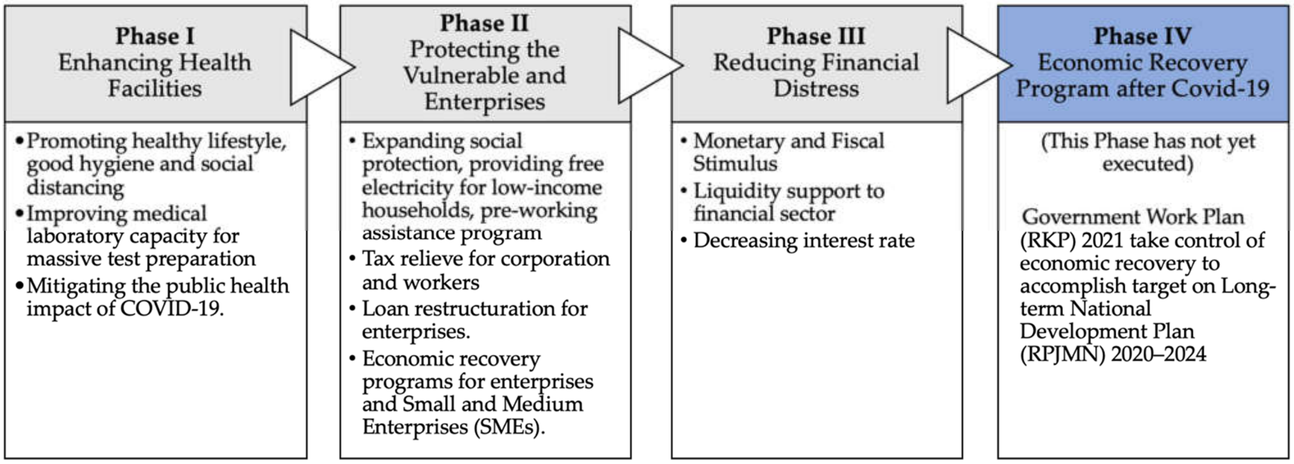

Figure 4. The timeline of COVID-19 mitigation policies (Modified from BAPPENAS [11]).

Table 1. Indonesia's fiscal stimulus against COVID-19 pandemic (Modified from Ministry of Finance [51]).

Fiscal Stimulus	Amount (IDR)	Amount (USD)
Health	87.55 Trillion	6.28 Billion
Social Protection	203.9 Trillion	14.62 Billion
Business Incentives	120.61 Trillion	8.65 Billion
SMEs	123.46 Trillion	8.85 Billion
Corporate Financing	53.57 Trillion	3.84 Billion
Sectoral and Regional Government	106.11 Trillion	7.61 Billion
Total	695.2 Trillion	49.85 Billion

In order to fund the COVID-19 mitigation and the PEN, the Indonesian President has issued the Indonesian President Instruction (Inpres) No. 4 year 2020 on government programs' refocusing, budget reallocating, and procurement of goods and services to accelerate COVID-19 mitigation [52]. The Inpres instructed all ministries, institutions, provincial governments, and local governments to reallocate their annual expenditures for COVID-19 mitigation and PEN [52,53]. Within Indonesian PEN, the largest amount of fiscal stimulus is allocated towards the social protection category, followed by SMEs, business incentives, sectoral and regional government, health, and corporate financing.

4. Research Methods

To study the impact of COVID-19 on SDGs in Indonesia, two steps of research were conducted in this study. Firstly, a methodical literature review was conducted to establish a basic understanding of the research subject. Relevant documents were identified from the selected research databases of Scopus, Science Direct, ResearchGate, and Springer by executing search queries for keywords such as "COVID-19", "SDGs", "COVID-19 fiscal stimulus" and "Indonesia". While the research documents related to COVID-19 and SDGs are still very few, a total of 83 research documents were identified (as of December 2020) through keyword search queries in all defined research databases. These documents were then sorted by their title and abstract to meet the relevance for this study, after which 16 of these documents were taken into consideration. In addition, an online search was also conducted to find relevant policies, official reports, and statistics from the government, international organizations, (Non-Governmental Organizations) NGOs, media releases, and academic research.

In the second step, semi-formal interviews (through online meeting platforms) were conducted with key stakeholders in Indonesia to substantiate the literature findings. The online mode was explicitly chosen with respect to the core need to maintain social distancing and to avoid any unintended consequences of this study. The key stakeholders were identified in consideration of their roles and responsibilities in SDG implementation and fiscal stimulus policy in Indonesia, which are mostly conducted by Indonesian government agencies. Thus, representatives from three different Indonesian government agencies were approached to be interviewed in this research: (1) SDGs Secretariat of BAPPENAS: the coordinating agency for SDGs Implementation in Indonesia; (2) Ministry of Finance: the agency that is responsible for fiscal policy; (3) Statistics Indonesia: the SDGs database coordinating agency. To further widen the range of stakeholders interviewed in this study, academic experts, NGOs, community groups, and the private sector were also identified based on their work on the field of SDG implementation in Indonesia.

During November–December 2020, a total of 11 interviews were conducted with a range of stakeholders from Indonesia as follows: one expert form the SDGs Secretariat of BAPPENAS, two experts from the Ministry of Finance Indonesia, two experts from Statistics Indonesia, one expert from SDGs Research Centre, two academic experts, one expert from an NGO, one expert from a community group, and one expert from the private sector.

Three broad research topics were prepared for guiding these interviews: (1) The impact of COVID-19 on SDG attainment in Indonesia; (2) The role of fiscal stimulus to keep SDG progress on track; (3) The impact of fiscal stimulus on SDG progress in Indonesia. Based on these topics, the authors prepared specific research questions to initiate the discussions during the semi-formal interviews as follows: (1) Describe the impact of the COVID-19 pandemic on SDG progress in Indonesia; (2) Which SDGs are the most affected by the pandemic?; (3) Do you think the fiscal stimulus will help to keep SDG progress on track?; (4) Which SDGs will be directly impacted by the fiscal stimulus?; (5) Which SDGs will be indirectly impacted by the fiscal stimulus?

The average duration for each of the interviews was around 60 min and all the interviews were documented. In order to effectively keep track of all interview responses, the authors also prepared matrices to list down the direct and indirect impacts on all 17 SDGs and the fiscal stimulus. These matrices were later brought to Microsoft Excel for analysis and data display. Based on the responses from the interviews, a deeper understanding regarding the impact of the COVID-19 pandemic on SDG implementation in Indonesia and the impact of fiscal stimulus towards SDG progress was established, and the literature findings were accordingly substantiated.

5. Results

5.1. Impacts of COVID-19 on SDGs in Indonesia

Based on the insights gained through the literature research and semi-formal interviews, it has been inferred that the progress of SDGs' realization in Indonesia was lagging even before the pandemic. The interviewees even raised specific concerns on the progress of SDG attainment in Indonesia before COVID-19, which are explained as follows:

1. Insufficient SDG knowledge dissemination

As a new development concept adopted from an international agreement, SDG knowledge was first disseminated at the national government level, from where the knowledge was transferred to provincial and city/regional governments. However, some stakeholders argued that the knowledge transfer had not been well implemented. A familiarity gap persists between the national government and other tiers of governments below it. The knowledge on SDGs and their implementation is primarily possessed by those in the national government, whereas the other government levels have inadequate knowledge of SDGs, let alone the ability to translate them into their development programs.

2. SDGs are not yet mainstreamed into the development programs in provincial and local government levels

Although it has been instructed by the national government of Indonesia to mainstream SDGs into development programs in all government levels, some stakeholders claimed that many provincial and local governments have not yet been able to do so. Through the interviews, it was discovered that certain government programs are not yet aligned with the SDGs, which hinders their progress. In addition, several programs are aligned with SDG attainment but are not yet synchronized on the programs' report. Herein, the interviewees highlighted that the SDG roadmap set by BAPPENAS is yet to be translated into development programs by all government levels and institutions, particularly provincial and city/regional governments.

The interviewees perceived that COVID-19 would delay Indonesia's progress towards achieving the SDGs. Further, some SDGs are perceived to be more impacted than others, especially those under the social and economic development pillars.

Derived through the stakeholder perception, Figure 5 below depicts the impact of the COVID-19 pandemic on the attainment of SDGs in Indonesia. The top three most impacted goals by COVID-19, according to stakeholders, are Goal 1 (No Poverty), Goal 8 (Decent Work and Economic Growth), and Goal 3 (Good Health and Well-being), while Goal 11 (Sustainable Cities and Communities), Goal 14 (Life Below Water), and Goal 15 (Life on Land) are perceived to have experienced little impact from COVID-19. The more specific impacts of COVID-19 on different SDGs in Indonesia are discussed in the following sub-sections, which are organized in accordance with the four pillars of sustainable development (explained in Section 3) defined by BAPPENAS, the coordinator of SDG implementation in Indonesia. The overall summary of the impacts of COVID-19 pandemic is depicted in Figure 6.

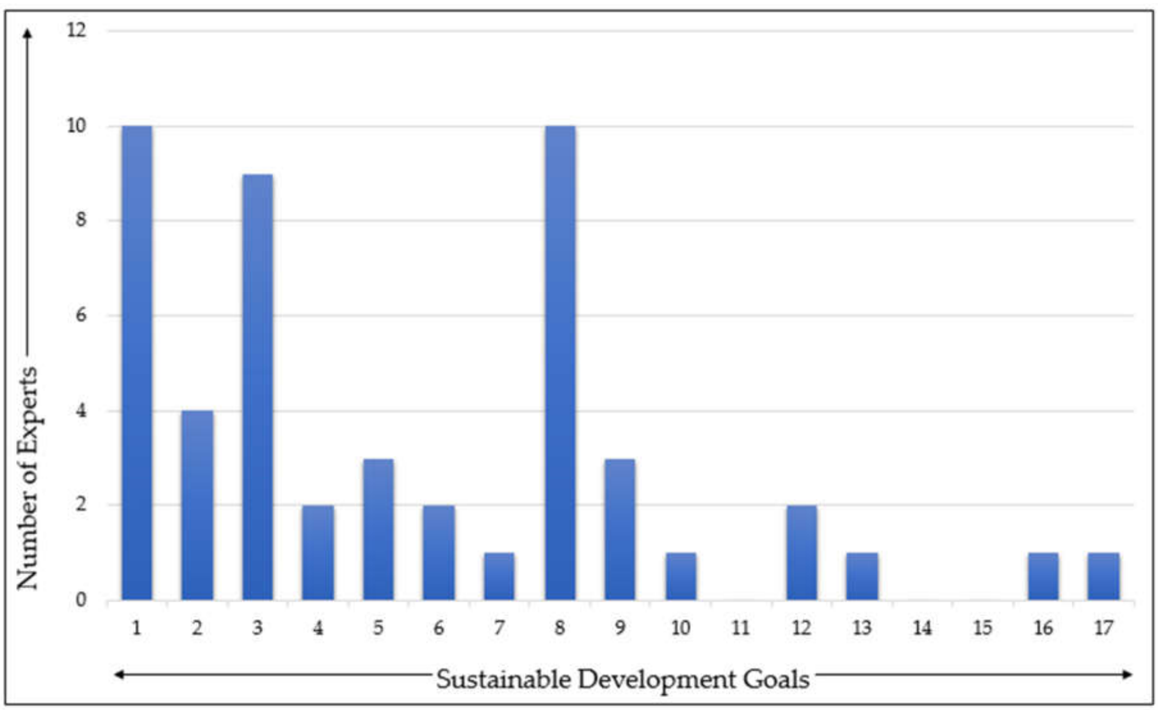

Figure 5. The impact of COVID-19 on SDGs identified by the stakeholders' interviews.

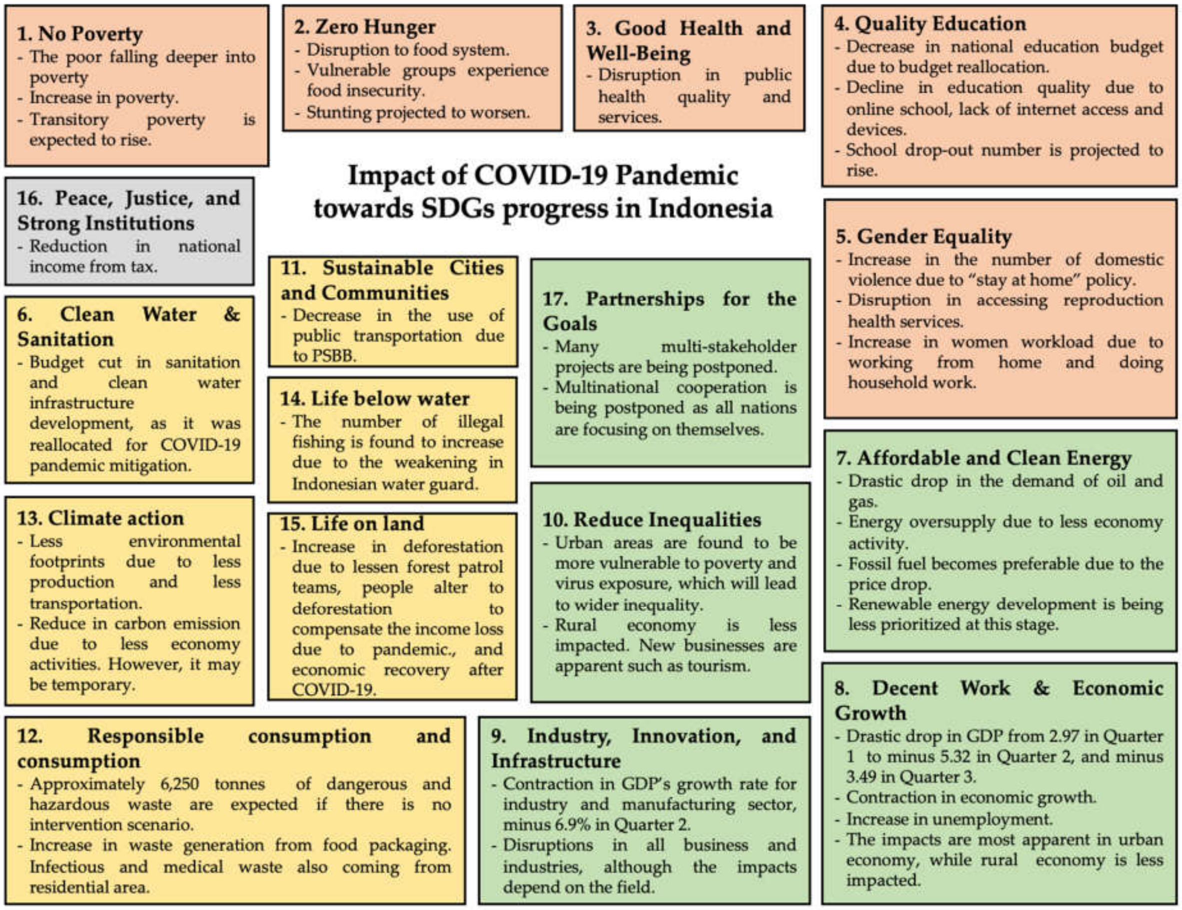

Figure 6. The summary of COVID-19 pandemic towards SDG progress in Indonesia.

5.1.1. Impacts on Social Development Pillar

In the wake of the COVID-19 pandemic, achieving SDG 1 (No Poverty) would be extremely challenging in Indonesia. The poverty rate is expected to rise as a result of large-scale social restriction policies which have been implemented by provincial, city, and regional governments all around Indonesia. Many people have lost their jobs and enterprises as a result of enforced social restrictions. The vulnerable groups of society are expected to fall into poverty, and those who are poor are expected to fall into deeper poverty. As per BAPPENAS [11], the poverty level is projected to reach 9.7–10.2% of the population. Additionally, according to the World Bank [54] survey, lower-middle-income households will face income shocks as a result of pandemic, with job losses in urban areas being more prevalent. These literature findings have also been corroborated with the stakeholder interviews, wherein it was pointed out that COVID-19 will likely exacerbate the poverty in Indonesia.

The disruption of the food system due to COVID-19 restrictions has raised concerns for SDG 2 (Zero Hunger). BAPPENAS [11] underlined that the people who experienced a reduction in income levels would see a decrease in the quality and quantity of food available, and the most disadvantaged members of the community may even experience hunger. Through the semi-formal interviews, it was reviewed that the number of stunting cases would likely worsen in the long run as a result of a decline in food nutrition. In that manner, COVID-19 may reverse the moderately growing development of SDG 2 (Zero Hunger).

The pandemic also has a major effect on SDG 3 (Good Health and Well-being) according to the stakeholders interviewed. While the disruption in public health is apparent, the public healthcare services are presently more focused on controlling the pandemic, which is likely to disrupt the whole public service.

The reallocation of the education budget for COVID-19 mitigation measures has impacted the national education program [55], as well as constrained the attainment of SDG 4 (Quality Education). To suppress the pandemic, the government has also implemented the school from home scheme, wherein the efficacy of online learning remains to be determined in the long run. Additionally, some students have been unable to access the online classes due to remote locations, a lack of sufficient devices, book and supplies, and financial constraints for internet access [56]. Through the semi-formal interviews, the potential issue of an increase in the school dropout number also came to light, as more students are projected to leave school to support the falling family incomes.

The achievement of SDG 5 (Gender Equality) is also affected by COVID-19. Several reports have highlighted the rise in physical assault cases within the first six weeks of the large-scale social restriction in Indonesia. From March to April 2020, the number of domestic violence cases was reported to be doubled [57]. The insights obtained from the semi-formal interviews further revealed that women are at greater risk due to the declining economy because they lack decision-making capacity, their basic needs are not met, and access to health reproduction services is restricted. Furthermore, working women now have more domestic responsibilities as well as the additional burden of childcare.

5.1.2. Impacts on Economic Development Pillar

SDG 7 (Affordable and Clean Energy) was perceived as hard to accomplish even before COVID-19. Since the pandemic, the progress has become much more hampered as the energy demands have plunged due to the closure of offices and shopping centers, and a drop in flight frequency. This has brought the fossil fuel price down significantly [11]. As a result, fossil fuel has once again outshone renewable energy sources [58]. Through the semi-formal interviews, it was highlighted that the research and development of clean and affordable energy will now be much less prioritized than before COVID-19, since the budget of renewable energy has been reallocated for COVID-19 mitigation.

The economic impact of the COVID-19 pandemic in Indonesia is highly prominent, making SDG 8 (Decent Work and Economic Growth) harder to attain. Indonesian economic growth contracted to minus 5.32% in the second quarter of 2020 [10]. The country has not experienced such a severe economic downturn since the 1998 Asian financial crisis [59]. Due to declining demand, the number of workers in the sub-sectors of trade, processing, transportation and warehousing, as well as accommodation, has decreased. Many workers in the tourism industry (cafes and restaurants) do not even have access to social security [11]. The economic growth contraction thus increases unemployment, especially for those in urban settings [59]. Further, through the stakeholder interviews, it was discovered that the rural area economy is less impacted because it is mainly supported by the agricultural sector. Additionally, new tourism sites have opened in rural areas that introduce COVID-19 spread prevention measures.

BAPPENAS [11] reported that the progress of SDG 9 (Industry, Innovation, and Infrastructure) has been affected by COVID-19 due to a range of its implications on various sectors, for example, the growth of the food and beverage industry has slowed down due to the fall in foreign demand. Because of the decline in tourism and air-travel, the aviation and tourism industries are also struggling to stay afloat. Aside from tourism, the Purchasing Manager Indexes (PMI) for manufacturing and the fiscal of imports to Indonesia have both been stated to be on the decline [11]. Through the semi-formal interviews, it was revealed that the impact of COVID-19 is dependent on the type of industry. Some industries, such as the tourism and manufacturing industries, experience harder impacts due to the large-scale social and mobility restriction. Other industries that involve export and import activities are disrupted by the lockdown policies worldwide which restrict the global trade.

While COVID-19 has widened the inequalities, the attainment of SDG 10 (Reduced Inequalities) has become far more challenging. Inequality has risen primarily due to the disproportionate impacts of COVID-19 on different social groups, such as on the informal sector. While the urban society has been shown to be more vulnerable to poverty, they are also at a higher risk of virus exposure due to high population density, slum living, and limited access to health services. Furthermore, the rural economy is less affected by the COVID-19 pandemic, at least in the early stages of the pandemic. Recently, the economy in rural areas has returned to normal, and in some cases has even grown because of the new opening for tourism with COVID-19 prevention measures.

While no scientific study has discussed the implication of COVID-19 on SDG 17 (Partnerships for The Goals), it is perceived to be impacted based on the semi-formal interviews. Many multi-stakeholder initiatives have been put on hold due to COVID-19, which will hamper the progress toward this goal. Multinational collaborations on various development projects have been postponed due to the fact that all countries are presently focusing on themselves.

5.1.3. Impacts on Environmental Development Pillar

SDG 6 (Clean Water and Sanitation) achievement was on track before COVID-19 [25]; however, in the semi-formal interviews, it was revealed that the sanitation and clean water infrastructure development budget has been reallocated for COVID-19 pandemic mitigation, which may slow down its progress.

SDG 11 (Sustainable Cities and Communities) is also impacted by COVID-19 in varying ways. According to BAPPENAS [24], the use of public transportation is declining due to the large-scale social restriction. While the means of public transportation have been constrained, people tend to commute more in their private vehicles to avoid crowds.

During the pandemic, the rise in medical waste and plastic packaging has been a major concern for the environment as people use disposable packaging to prevent the spread of the virus [11]. Without an intervention scenario, approximately 6250 tons of dangerous and hazardous waste are expected to be generated [60], posing a threat to the achievement of SDG 12 (Responsible Consumption and Production).

In relation to SDG 13 (Climate Action), the pandemic reduced the commitment to Climate Action [61]. According to the semi-informal interviews, the large-scale social restrictions to mitigate COVID-19 impacts have resulted in a reduction in carbon emissions; however, after the pandemic ends, these emissions could significantly increase. While the environment is undoubtedly improving in the meantime due to reduced economic activities, BAPPENAS [11] highlighted that the air quality in many major cities in Indonesia has improved due to the large-scale social restriction. However, the stakeholder interviews perceived that this positive impact will only be temporary because post-pandemic economic recovery policies will most likely be introduced with Business-as-Usual (BAU) orientation instead of a green-economy approach.

The data availability for SDG 14 (Life Below Water) was limited even before the pandemic, and the pandemic has further exacerbated the situation, making it difficult to understand the impacts of COVID-19 on the attainment of this goal [12]. Regardless, there has been a growing concern regarding this goal's progress during the pandemic. The number of illegal fishing incidents increased during the pandemic due to fewer patrols on Indonesian water [12,62].

For Goal 15 of Life on Land, the extent of deforestation is found to be increasing during the pandemic [63]. While the pandemic has affected many households due to job loss, deforestation has become one of the solutions to feed the family. Moreover, the patrol teams in forest areas are not fully operational due to the pandemic. Thus, illegal activities are easier to be executed [64]. What is more concerning is that once the pandemic is controlled, the economic recovery will almost certainly be accompanied by increased deforestation due to loosening regulations and patrols [65].

5.1.4. Impacts on Law and Governance Development Pillar

Goal 16 (Peace, Justice, and Strong Institutions) is affected by the pandemic as the restriction on public services on court processes disrupts the stability in the legal and judicial fields [66]. Further, during the semi-informal interview, the key stakeholders disclosed that the tax revenue will likely experience a significant contraction due to the economic slowdown and stimulus provision.

Herein, the impacts of COVID-19 towards SDGs attainment in Indonesia have been presented, combining both literature review and stakeholder interviews as depicted in Figure 6 below.

5.2. Role of Fiscal Measures to Keep SDGs on Track

Based on the understanding obtained through the semi-formal interviews, fiscal measures under the national economic recovery of Indonesia were initiated as emergency measures to alleviate the impact of the COVID-19 pandemic. They were launched with the primarily goal of addressing the health fallout of the pandemic, while simultaneously mitigating social and economic impacts. Along the way, the Indonesian government has pledged to align the economic recovery measures with the SDG framework. The purpose was to expand the impact of fiscal stimulus measures to not only respond quickly to the repercussions of the COVID-19 pandemic but also to keep the 2030 sustainable development agenda on track [67]. Broadly, the fiscal measures are perceived to contribute to maintaining the SDGs' progress in Indonesia in three core development pillars (explained in Table 2), and limited contribution is expected towards the pillar of law and governance development.

Table 2. Role of fiscal measures in SDG progress in Indonesia.

Goals	Role of Fiscal Measures in SDG Progress in Indonesia
Social Development Pillar	• Fiscal measures act as an intervention which can prevent the poverty rate worsening. Without the social protection relief measures, The World Bank's Indonesia COVID-19 Observatory [67] estimated that potentially 5.5 to 8 million Indonesian people may fall into poverty. In addition, government emergency packages assist the people in supplementing the reduced non-food and food expenditure [59,68]. • Fiscal measures will help in ensuring food security, accessibility and food quality for the civilians and maintain the infants' stunting rate. • Fiscal measures under the health category amounting to USD 6.2 billion will contribute to ensuring the accessibility of health services for more people by widening national health insurance coverage. • Fiscal measures will contribute to ensuring the quality of education by providing aid for cellular data. • Fiscal measures targeting SMEs will help women to keep their business afloat.
Economic Development Pillar	• Electricity subsidies will assist people to ensure that their households have access to energy during the economic downturns [69]. • Pre-working scheme enables the unemployed to gain access to career training to develop their skills. They

	will also obtain an extra cash transfer after finishing the training. • Business and corporate incentives are aimed at labor-intensive programs in order to increase multiplier effects. • Although economic growth is still contracting, fiscal measures are perceived to prevent the Indonesian economy from worsening.
Environmental Development Pillar	• Sectoral and regional government stimulus contribute to achieving the goal of Sustainable Cities and Communities. • Some programs under the sectoral and regional category are geared toward fighting climate change. • However, Hadi et al. [70] argued that the stimulus provided by the National Economic Recovery Plan of Indonesia is primarily targeted at sectors which contribute significantly to Green House Gas (GHG) emissions. The orientation of the National Economic Recovery Program (PEN) remains based on business as usual, with no long-term green economy orientation [71].

Although it is perceived that fiscal measures may help to keep the attainment of Indonesian SDGs on track, several concerns were highlighted by the stakeholders interviewed in regard to the implementation of fiscal measures:

1. The possibility of misconduct in stimulus implementation

The key interviewees argued that although the amount allocated for fiscal stimulus is not as large as expected, it will at least benefit vulnerable people, if well implemented without any misconduct such as corruption and fraud. However, the possibility of misconduct is rather high owing to the lack of accountability in the stimulus delivery process. Clean, transparent, and accountable tender mechanisms may be overlooked for the sake of ensuring a speedy stimulus implementation. This concern is also highlighted by The United Nations Office on Drugs and Crime (UNODC) [72], which stated that, under the Indonesian Government Regulation (Perpu) No. 1 Year 2020 on State Financial Systems for the Management of Corona Virus Disease 2019 (COVID-19) and/or Encounter the Threat to National Economy and/or Financial Stability, the government officials are exempted from civil and criminal liability during the implementation of this regulation if it is based on "goodwill and according to the law". However, the definition and criteria of "goodwill" have yet to be established. Thus, it can open up a chance of misconduct.

2. Unsynchronized database at all government institutions

The semi-formal interviews revealed that the social protection fiscal measures may be beneficial only if they are delivered to the accurate beneficiaries. However, some interviewees highlighted that the database used for fiscal measure distribution is poorly maintained and updated. Each ministry has its own database, and so have the provincial and city/regional governments. These databases have not yet been integrated across government institutions and at all levels. As the accuracy of the beneficiary data is still inadequate, the distribution of social protection packages is often disrupted. For instance, during the ongoing COVID-19 crisis, some households received the social protection packages despite not meeting the eligibility criteria, while there have been cases where qualifying recipients were overlooked.

3. Lack of resources and capacity in fiscal measures' implementation

A large number of fiscal measures are distributed by the local governments in Indonesia. However, some interviewees argued that the local governments have not yet obtained sufficient capacity in managing a huge amount of emergency budget which must be distributed in a short period of time. This could lead to further implementation problems such as delayed delivery and a chaotic distribution process. The new work-from-home setting caused by COVID-19 has also hampered the fiscal measures' implementation. The stakeholders perceived that the Indonesian government is not yet able to adopt a work-from-home setting both in terms of the manpower capacity and infrastructure.

5.3. Perceived Direct and Indirect Impact of Fiscal Measures on SDGs' Progress

Figure 7 illustrates the perceived direct impact of fiscal measures on SDGs' progress in Indonesia based on the stakeholders' semi-formal interviews. The bar illustrates the perceived direct impact of each fiscal stimulus category towards all 17 SDGs. The number in each colored bar represents the number of stakeholders (out of 11 stakeholders interviewed) who perceived the direct impact of each stimulus to corresponding SDGs.

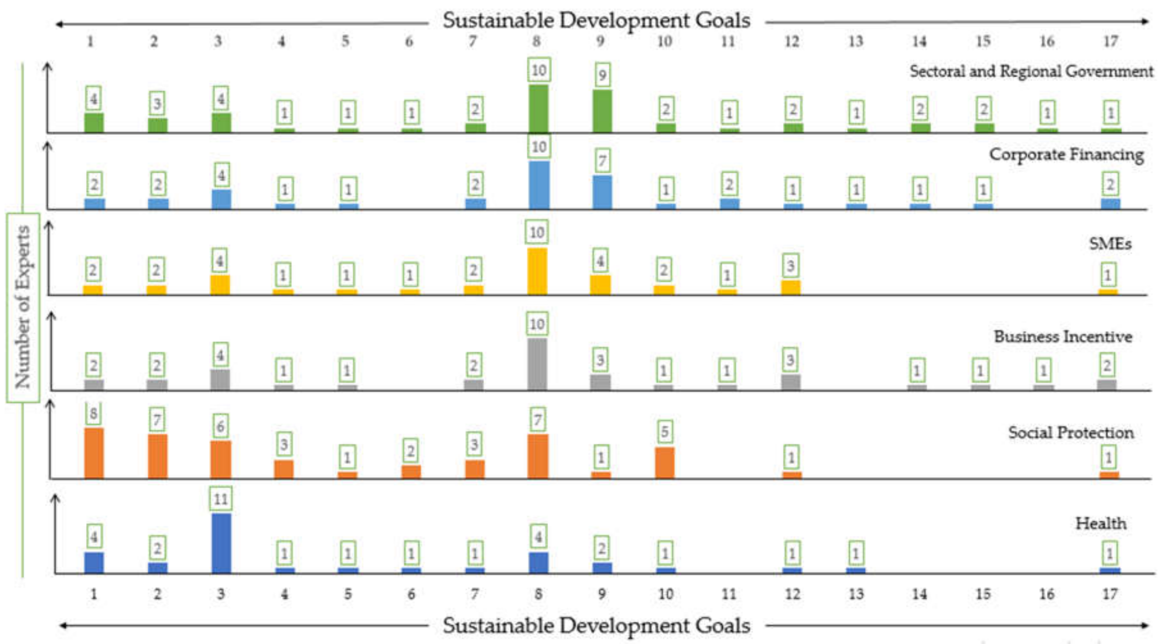

Figure 7. Perceived direct impact of fiscal measures on SDG progress in Indonesia.

Noticeably, the goals within the "economic" and "social development" categories are perceived to be the most directly impacted goals by the fiscal measures. However, goals under the environmental and law and governance development categories do not experience as much direct impact. Most stakeholders regarded that SDG 8 (Decent Work and Economic Growth) will be mostly impacted directly by the stimulus, followed by SDG 3 (Good Health and Well-being), and SDG 9 (Industry, Innovation, and Infrastructure), respectively. The reason is that the stimulus is largely allocated towards economic recovery, whether through SMEs financing, business incentives, sectoral and regional governments, and corporate financing.

The stimulus on the sectoral and regional government category is recognized as being able to give a direct impact to all 17 SDGs, although the amount of the budget allocation is not as high as other economy related stimulus categories. It is because the stimulus aimed for the sectoral and regional government will be spent by ministries and local governments all over Indonesia for a variety of purposes. This stimulus enables the Indonesian government in all levels to execute a broad range of programs that may cover all

SDGs, unlike other stimulus categories which are specifically addressing only those within their field.

Figure 8 highlights the indirect impacts of fiscal measures towards SDGs obtained from the stakeholders' interviews. Although the "social" and "economic development" pillars are perceived to remain dominant in experiencing indirect impacts of the stimulus, the goals under the "environmental development" pillar are expected to be impacted as well in the future. Notably, the stakeholders perceived that none of the fiscal measures will address SDG 7 of Affordable and Clean Energy. They argued that achieving clean and affordable energy will be even less prioritized during economic recovery. The SDGs under the environmental development pillar, SDG 6 (Clean Water and Sanitation), SDG 11 (Sustainable Cities and Communities), SDG 12 (Responsible Consumption and Production), SDG 13 (Climate Action), SDG 14 (Life Below Water), and SDG 15 (Life on Land), would thus be impacted in the future as a prolonged impact of the stimulus.

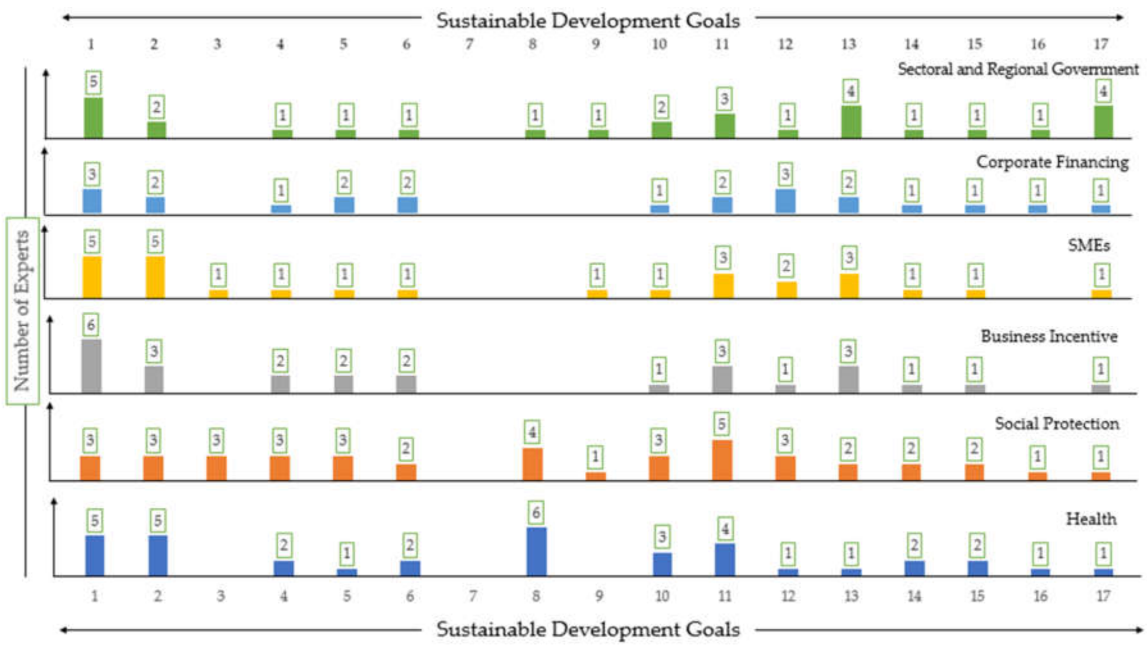

Figure 8. Perceived indirect impact of fiscal measures on SDG progress in Indonesia.

6. Discussion

Evident through the research findings, the attainment of SDGs in Indonesia has been impacted by the pandemic (as also discussed in Section 5.1), although there are some gaps in comparison to the UN assessment of the short-term impacts of COVID-19 on SDGs (highlighted in Section 2.2). Based on semi-formal interviews, the stakeholders perceived that COVID-19 has a significant effect on SDG 1 (No Poverty), SDG 3 (Good Health and Well-being), and SDG 8 (Decent Work and Economic Growth). Meanwhile, based on the UN assessment, SDG 2 (Zero Hunger) and SDG 10 (Reduced Inequality) are also assessed as highly negatively impacted by COVID-19.

Further, like many other nations around the world, the Government of Indonesia has also taken fiscal measures to mitigate the multisector fallouts from the COVID-19 pandemic. The economic packages launched by the Indonesian government are aimed to support domestic consumption and prevent rapid poverty and rising unemployment. Although the fiscal measures do not explicitly seek to minimize the impacts of COVID-19 on SDGs, it can be concluded based on the semi-formal interviews that the fiscal measures would have a direct impact on SDG 8 (Decent Work and Economic Growth) and SDG 3

(Good Health and Well-being) (explained in Section 5.3), in which these goals are perceived as highly impacted by COVID-19 based on the UN assessment of COVID-19's short term impacts on SDGs (refer to Section 2.2).

Based on the understanding gained through the existing literature and semi-formal interviews, the authors suggest specific policy recommendations (in the following three subsections) to address the identified concerns on fiscal measures and SDG implementation in Indonesia (presented in Section 5.1).

6.1. Ensuring Good Governance Practice

As discussed in Section 5.2, fiscal measures for COVID-19 mitigation require the Indonesian government to administer a significant amount of money intended to benefit the people and the economy. However, the government is under pressure to complete everything within a short period of time. Executing fiscal measures in such a tight timeframe necessitates more resources and capacity, which some stakeholders perceived that the government is lacking (refer to Section 5.2). Additional havoc on government bureaucracies came from the work-from-home and mobility restrictions policy. An online setting in doing government jobs adds more challenges in orchestrating fiscal measure implementation. To compensate such shortcomings, it is important for the government to be agile in facing the crisis and to come up with innovations that are data-driven and science-based to compensate the shortcomings on resources and capacity. Moreover, good and strong coordination among government institutions and across government levels are essential to ensure the effectivity in fiscal package distribution, which is also emphasized by Antara News [73].

As highlighted in Section 5.2, there is a risk of misconduct in the implementation of emergency packages to mitigate the COVID-19 pandemic. These emergency packages may possibly have been implemented with the absence of necessary inspection procedures and mechanisms with an aim to expedite packages' distribution to those in need. Therefore, potential fraud, misuse, and corruption are increasing [72]. As discussed in Section 5.2, the stakeholder interviews highlighted that good governance practice is required to ensure there is no leakage and fraud in the process of implementing and distributing the fiscal measures from the government to the people. Although some have argued that the amount of the stimulus is insufficient to prevent poverty from worsening, at least it can help even a little bit. Therefore, it is important to implement clean and transparent governance of the fiscal stimulus packages.

6.2. Integrating Beneficiaries' Database to Improve Accuracy of Targeted Groups

The allocation of the economy packages for social protection has brought forth concerns from the key stakeholder perception (explained in Section 5.2). Some interviewees stated that the budget allocated for social protection is not sufficient to overcome the economic repercussions of the COVID-19 pandemic. Sparrow et al. [62] also highlighted that the method of distribution for the social protection stimulus was based on pre-COVID-19 schemes, such as direct fund transfer (BLT), the Hopeful Families Program (PKH), the food assistance program, and the village cash support program. These existing schemes mostly target rural areas and the poor. However, based on the insights gained from the semi-formal interviews, the pandemic hits people in urban areas harder due to reduced income and job loss (Section 5.1). It is the lower-middle-income households which are prone to economic shocks due to the pandemic. Many are likely to fall into poverty for the first time, and others may fall back into poverty. Therefore, the current schemes of social protection package distribution may not address those newly poor households.

As the schemes are organized by different ministries, the beneficiaries' database is not integrated across ministries and each ministry has its own database (Section 5.2). This has caused overlap and outdated data in emergency package distribution. Some households who are not in poverty accepted the emergency packages, while some poor families have not been identified as beneficiaries. Thus, integrating databases across ministries and governmental levels is essential to improve the accuracy of the targeted beneficiaries in the distribution of emergency packages. The COVID-19 pandemic amplifies the importance of an innovative information system which is well integrated and can accommodate a rapid data change.

6.3. Mainstreaming SDGs at Different Government Levels

As the Indonesian government is committed to mainstream SDGs in its economic recovery program, it is imperative to ensure the mainstreaming of SDGs in all government institutions and across all government levels. The stakeholders interviewed in this study also highlighted that one of the key challenges of attaining SDGs in Indonesia is the gap of knowledge of the SDGs themselves existing within the government institutions, as discussed in Section 5.1. The stakeholders' perception is also highlighted, which stated that many local governments have not yet synchronized their programs to SDGs, although they have been instructed to by the central government. The reason is that they do not yet have comprehensive knowledge about SDGs; therefore, they cannot identify whether or not their programs are aligned or could be aligned with SDGs. As sectoral and regional governments are included as the fiscal stimulus beneficiaries under PEN, it is important to allocate this stimulus to programs that are aligned with SDGs.

7. Conclusions

While the wide-ranging implications of COVID-19 on SDGs worldwide are yet to be fully understood, this study presented a specific overview of COVID-19 implications on SDGs for the context of Indonesia. Building over the foundation of the existing literature, semi-formal interviews were conducted with the key stakeholders in Indonesia that are directly involved in the implementation of SDGs. In addition to identifying the most affected SDGs through specifically defined interview questions, this study has also derived the perceived direct and indirect impacts of the fiscal stimulus measures on different SDGs. In the backdrop of the limited research conducted so far on the implications of COVID-19, it is hoped that this research will provide useful insights and directions to the decision makers for enhancing the implementation of SDGs in the post COVID-19 era.

The findings highlighted that COVID-19 impacts all 17 SDGs, although disproportionately. Based on the four pillars of sustainable development defined in Indonesia, the SDGs in the social and economic development pillars are seen to be most impacted by COVID-19, while the pillars of environmental and law and governance development are not as highly impacted. The semi-formal interviews also helped to identify the role of fiscal measures in maintaining SDG progress, wherein the fiscal stimulus is perceived to be able to help in maintaining the SDG progress to some extent, except in the law and governance development pillar. The direct and indirect impacts of the stimulus towards each SDG were also identified. Further, the semi-formal interviews, as the key strength of this study, have also brought forward the stakeholders' concerns on the progress of SDG implementation and fiscal stimulus implementation.

This study contributes to the existing knowledge of COVID-19, SDGs, and fiscal stimulus by providing a precise overview of COVID-19's impacts on SDG attainment in the specific case of Indonesia. Building over the country's governance profile and fiscal stimulus measures against the COVID-19 pandemic, the study methodically presented the research findings based on a literature review and stakeholder interviews. Through this study, specific policy recommendations were derived, in which they were established based on the stakeholders' concerns on the COVID-19 fiscal measure implementation. Deriving specific lessons from the case of Indonesia, the study also highlighted the core need for aligning the COVID-19 fiscal stimulus with SDG attainment in order to keep the local level progress of SDGs on track, which is now is highlighted as necessary to be done.

Towards the end, it is important to acknowledge the following limitations of this research. The study has been conducted in reference to the existing literature on COVID-

19's impacts on Indonesia and semi-formal interviews with the key stakeholders. However, the implications of the COVID-19 pandemic for SDGs may further transform, until the pandemic is fully controlled. As such, the future scope of this study necessitates a further detailed literature analysis and stakeholder perception study. It is also important to note that this research was mainly conducted through the online mode, but there is a further need for primary surveys in the field, and analysis of the secondary data. The future scope of this study also includes the mapping of the before and after COVID-19 progress of SDGs to determine the development gaps based on both primary and secondary data, and accordingly, to work for the timely attainment of SDGs. Another possible area of future research would be to investigate the impact of the COVID-19 pandemic on the environmental related goals with more data availability.

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References

1. Time. World Health Organization Declares COVID-19 a 'Pandemic.' Available online: https://time.com/5791661/who-coronavirus-pandemic-declaration/ (accessed on 11 December 2020).
2. World Health Organization. WHO Coronavirus Disease (COVID-19) Dashboard. Available online: https://covid19.who.int/ (accessed on 5 March 2021).
3. Chakraborty, I.; Maity, P. COVID-19 outbreak: Migration, effects on society, global environment and prevention. *Sci. Total Environ.* **2020**, *728*, 138882.
4. World Health Organization. Impact of Covid-19 on People's Livelihoods, Their Health and Our Food Systems. Available online: https://www.who.int/news/item/13-10-2020-impact-of-covid-19-on-people's-livelihoods-their-health-and-our-food-systems (accessed on 31 December 2020).
5. The United Nations. The Sustainable Development Goals Report 2020. Available online: https://unstats.un.org/sdgs/report/2020/The-Sustainable-Development-Goals-Report-2020.pdf (accessed on 3 January 2021).
6. Asia Society. ASEAN's Way to Sustainable Development. Available online: https://asiasociety.org/australia/aseans-way-sustainable-development (accessed on 11 January 2021).
7. Reporting ASEAN. Southeast Asia: Talking Green, Going Green after COVID-19? Available online: https://www.reportingasean.net/southeast-asia-green-covid-19/ (accessed on 11 January 2021).
8. United Nations. Indonesia Multi-Sectoral Response Plan to Covid-19: Jakarta, Indonesia, 2020. Available online: https://reliefweb.int/sites/reliefweb.int/files/resources/covid19-msrp-v7.pdf (accessed on 22 November 2020).
9. Satuan Tugas Penanganan Covid-19. Peta Sebaran Covid-19. Available online: https://covid19.go.id/peta-sebaran (accessed on 5 March 2021).

10. Statistic Indonesia. Pertumbuhan Ekonomi Indonesia Triwulan II-2020; Berita Resmi Statistik No. 64/08/Th. XXIII, Indonesia, Jakarta, 2020. Available online: https://www.bps.go.id/pressrelease/2020/08/05/1737/-ekonomi-indonesia-triwulan-ii-2020-turun-5-32-persen.html (accessed on 1 January 2021).
11. BAPPENAS. Pengaruh COVID-19 terhadap Tujuan Pembangunan Berkelanjutan. Available online: https://kkp.go.id/an-component/media/upload-gambar-pendukung/DitJaskel/publikasi-materi-2/SDGs-Talks-Menjaga-Momentum/20200506%20Final%20Paparan%20Deputi%20KSDA%20SDG%20IPB%20-%20sec.pdf (accessed on 13 October 2020).
12. SDGs Center Unpad. Tantangan Pencapaian SDG 14 Dengan Adanya Pandemi Covid-19. Available online: http://sdgcenter.unpad.ac.id/the-presentations-from-webinar-tantangan-pencapaian-sdg14-dengan-adanya-pandemi-covid-19/ (accessed on 13 October 2020).
13. Sachs, J.; Schmidt-Traub, G.; Kroll, C.; Lafortune, G.; Fuller, G.; Woelm, F. The Sustainable Development Goals and COVID-19. In *Sustainable Development Report 2020*; Cambridge University Press: Cambridge, UK, 2020. Available online: https://s3.amazonaws.com/sustainabledevelopment.report/2020/2020_sustainable_development_report.pdf (accessed on 20 October 2020).
14. Ministry of Finance. Langkah Penguatan Perlindungan Sosial dan Stimulus Ekonomi Manghadapi Dampak Covid-19. Available online: https://www.kemenkeu.go.id/media/14790/materi-konferensi-pers-1-april-2020.pdf (accessed on 14 October 2020).
15. Ministry of Finance. Triwulan III 2020, Pertumbuhan Ekonomi Indonesia Tunjukkan Perbaikan Signifikan. Available online: https://www.kemenkeu.go.id/publikasi/berita/menkeu-triwulan-iii-2020-pertumbuhan-ekonomi-indonesia-tunjukkan-perbaikan-signifikan/#:~:text=%E2%80%9CPada%20triwulan%20III%202020%2C%20perekonomian,%2C32%25%20(YoY) (accessed on 1 January 2021).
16. Statistic Indonesia. Pertumbuhan Ekonomi Indonesia Triwulan III-2020; Berita Resmi Statistik No. 85/11/Th. XXIII, Indonesia, Jakarta, 2020. Available online: https://www.bps.go.id/pressrelease/2020/11/05/1738/ekonomi-indonesia-triwulan-iii-2020-tumbuh-5-05-persen--q-to-q-.html (accessed on 1 January 2021).
17. United Nations Department of Economic and Social Affairs. Achieving the SDGs through the COVID-19 Response and Recovery. Available online: un.org/development/desa/dpad/wp-content/uploads/sites/45/publication/PB_78.pdf (accessed on 8 December 2020).
18. OECD. 2020-Building Back Better: A Sustainable, Resilient Recovery after COVID-19. Available online: https://blogs.worldbank.org/transport/wake-call-building-back-better-achieve-sustainable-mobility-all (accessed on 18 January 2021).
19. The International Institute for Sustainable Development (IISD). Spending to Build Back Better. Available online: https://www.iisd.org/sustainable-recovery/spending-to-build-back-better (accessed on 18 January 2020).
20. The United Nations Department of Economic and Social Affairs. The 17 Goals. Available online: https://sdgs.un.org/goals (accessed on 3 January 2021).
21. The United Nations Department of Economic and Social Affairs. Transforming our World: The 2030 Agenda for Sustainable Development. Available online: https://sdgs.un.org/2030agenda (accessed on 17 December 2020).
22. The World Bank Blogs. The Redistributive Impact of Fiscal Policy Indicator: A New Global Standard for Assessing Government Effectiveness in Tackling Inequality within SDG Framework. Available online: https://blogs.worldbank.org/opendata/redistributive-impact-fiscal-policy-indicator-new-global-standard-assessing-government (accessed on 20 December 2020).
23. Filho, W.; Brandli, L.; Salvia, A.; Rayman-Bachus, L.; Platje, J. COVID-19 and the UN Sustainable Development Goals: Threat to Solidarity or an Opportunity? *Sustainability* **2020**, *12*, 5343.
24. Sachs, J.; Schmidt-Traub, G.; Kroll, C.; Lafortune, G.; Fuller, G. *Sustainable Development Report 2019*; Bertelsmann Stiftung and Sustainable Development Solutions Network: New York, NY, USA, 2019. Available online: https://s3.amazonaws.com/sustainabledevelopment.report/2019/2019_sustainable_development_report.pdf (accessed on 19 October 2020).
25. Barbier, E.; Burgess, J. Sustainability and Development after COVID-19. *World Dev.* **2020**, *135*, 105082.
26. The United Nations Department of Economic and Social Affairs. Policy Brief: Impact of COVID-19 on SDG Progress: A Statistical Perspective. Available online: https://www.un.org/development/desa/dpad/publication/un-desa-policy-brief-81-impact-of-covid-19-on-sdg-progress-a-statistical-perspective/ (accessed on 12 December 2020).
27. UNDP. COVID-19 and the SDGs: How the 'Roadmap for Humanity' Could be Changed by a Pandemic. Available online: https://feature.undp.org/covid-19-and-the-sdgs/ (accessed on 3 January 2021).
28. IOM UN Migration. How Will COVID-19 Affect the Achievement of the Goals of the 2030 Agenda? Available online: https://rosanjose.iom.int/SITE/en/blog/how-will-covid-19-affect-achievement-goals-2030-agenda (accessed on 5 January 2021).
29. UNDP. Development Goals. Available online: https://sdgintegration.undp.org/accelerating-development-progressduring-covid-19 (accessed on 5 January 2021).
30. UNDP. The Social and Economic Impact of COVID-19 in the Asia-Pacific Region. Bangkok, Thailand, 2020. Available online: https://www.undp.org/content/undp/en/home/librarypage/crisis-prevention-and-recovery/the-social-and-economic-impact-of-covid-19-in-asia-pacific.html (accessed on 5 January 2021).
31. Mukarram, M.M. Impact of COVID-19 on the UN Sustainable Development Goals (SDGs). *Strateg. Anal.* **2020**, *44*, 253–258.
32. Adiyoso, W. Does the COVID-19 pandemic have any positive impact on SDGs? *J. Indones. Sustain. Dev. Plan.* **2020**, *1*, i–iii.
33. Coenen, G.; Kilponen, J.; Trabandt, M. When Does Fiscal Stimulus Work? ECB Research Bulletin, No. 10, 2010. Available online: https://www.researchgate.net/publication/284757072_When_does_fiscal_stimulus_work (accessed on 3 January 2020).
34. Fuss, J.; Whalen, A.; Hill, T. Is Fiscal Stimulus an Effective Policy Response to a Recession? Reviewing the Existing Research. Available online: https://www.fraserinstitute.org/sites/default/files/is-fiscal-stimulus-an-effective-policy-response-to-a-recession.pdf (accessed on 3 January 2021).

35. Cassim, Z.; Handjiski, B.; Schubert, J.; Zouaoui, Y. *Public Sector Practise, The $10 Trillion Rescue: How Governments Can Deliver Impact*; McKinsey & Company: New York, NY, USA, 2020. Available online: https://www.mckinsey.com/~/media/McKinsey/Industries/Public%20Sector/Our%20Insights/The%2010%20trillion%20dollar%20rescue%20How%20governments%20can%20deliver%20impact/The-10-trillion-dollar-rescue-How-governments-can-deliver-impact-vF.pdf (accessed on 3 January 2020).
36. OECD. COVID-19 Crisis Response in ASEAN Member States. Available online: http://www.oecd.org/coronavirus/policy-responses/covid-19-crisis-response-in-asean-member-states-02f828a2/ (accessed on 3 January 2021).
37. International Monetary Fund. Fiscal Monitor: Policies for the Recovery. Washington, WA, USA, 2020. Available online: https://www.imf.org/en/Publications/FM/Issues/2020/09/30/october-2020-fiscal-monitor (accessed on 3 January 2021).
38. UNESCAP. Covid-19 and South Asia: National Strategies and Subregional Cooperation for Accelerating Inclusive, Sustainable and Resilient Recovery. Available online: https://www.researchgate.net/publication/343501685_COVID-19_and_South_Asia_National_Strategies_and_Subregional_Cooperation_for_Accelerating_Inclusive_Sustainable_and_Resilient_Recovery_COVID-19_and_South_Asia_National_Strategies_and_Subregional_Cooper (accessed on 3 January 2021).
39. UNDESA. Responding to COVID-19 and Recovering Better. New York, USA, 2020. Available online: https://www.un.org/development/desa/en/wp-content/uploads/2020/07/PB-Compilation-final.pdf (accessed on 3 January 2021).
40. Zhang, Y.; Thelen, N.; Rao, A. Social Protection in Fiscal Stimulus Packages: Some Evidence. New York, USA, 2010. Available online: http://www.undp.org/content/dam/undp/library/corporate/Development%20Studies/socialprotection_fiscalstimulus_march2010.pdf (accessed on 3 January 2021).
41. Library of Congress-Federal Research Division. Country Profile: Indonesia. 2004. Available online: https://www.loc.gov/rr/frd/cs/profiles/Indonesia.pdf (accessed on 4 January 2021).
42. Krishnamohan, T. The Local Government System in Indonesia and Sri Lanka: A Comparative Overview. *Int. J. Commer. IT Soc. Sci.* **2016**, *3*, 1–15.
43. Ministry of Public Works and Housing. Buku Informasi Statistik 2017. Sekretariat Jenderal, Pusat Data dan Teknologi Informasi (Pusdatin), Jakarta, Indonesia. 2017. Available online: https://setjen.pu.go.id/source/File%20pdf/Buku%20Induk%20Statistik/Buku%20Induk%20Statistik%20Tahun%202017.pdf (accessed on 12 January 2021).
44. Nasution, A. Government Decentralization Program in Indonesia, ADBI Working Paper 601, Tokyo: Asian Development Bank Institute. Jakarta, Indonesia, 2016. Available online: https://www.adb.org/publications/government-decentralization-program-indonesia/ (accessed on 12 January 2021).
45. Statistic Indonesia. Jumlah Penduduk Hasil Proyeksi Menurut Provinsi dan Jenis Kelamin (Ribu Jiwa), 2018–2020. Available online https://www.bps.go.id/indicator/12/1886/1/jumlah-penduduk-hasil-proyeksi-menurut-provinsi-dan-jenis-kelamin.html (accessed on 5 January 2021).
46. Statistic Indonesia. Pertumbuhan Ekonomi Indonesia Triwulan I-2020; Berita Resmi Statistik No. 39/05/Th. XXIII, Indonesia, Jakarta, 2020. Available online: https://www.bps.go.id/pressrelease/2020/05/05/1736/ekonomi-indonesia-triwulan-i-2020-tumbuh-2-97-persen.html (accessed on 1 January 2021).
47. Pratiwi, D.R. Analisis RKP dan Pembicaraan Pendahuluan APBN. Pusat Kajian Anggaran Badan Keahlian Setjen DPR RI: Indonesia, Jakarta, 2020. Available online: https://berkas.dpr.go.id/puskajianggaran/analisis-apbn/public-file/analisis-apbn-public-46.pdf (accessed on 5 January 2021).
48. Statistic Indonesia. *Indikator Tujuan Pembangunan Berkelanjutan Indonesia 2019*; Statistics Indonesia: Jakarta, Indonesia, 2019.
49. BAPPENAS. Dokumen SDGs. Available online: http://sdgs.bappenas.go.id/dokumen/ (accessed on 20 December 2020).
50. The Jakarta Post. Air Quality in Jakarta is Improving, for Now. Available online: https://www.thejakartapost.com/news/2020/04/14/air-quality-in-jakarta-is-improving-for-now.html (accessed on 15 October 2020).
51. Ministry of Finance. Dukungan Fiskal di Tengah Pandemi COVID-19 dan Pencapaian Target NDC Pasca Pandemi. Available online: https://www.enviro.or.id/wp-content/uploads/2020/06/Dr.-Adi-Budiarso.pdf (accessed on 13 October 2020).
52. JDIH Jaringan Dokumentasi & Informasi Hukum Badan Pemeriksa Keuangan Republik Indonesia. Realokasi Anggaran Untuk Penangangan Corona. Available online: https://jdih.bpk.go.id/wp-content/uploads/2020/04/Realokasi-Anggaran-utk-penanganan-corona.pdf (accessed on 2 December 2020).
53. Kementrian Keuangan Direktorat Jenderal Perimbangan Keuangan. Refocusing dan Realokasi Anggaran Pemerintah Daerah dalam Rangka Penanganan COVID-19. Available online: http://www.djpk.kemenkeu.go.id/?p=15836 (accessed on 4 December 2020).
54. The World Bank's Indonesia COVID-19 Observatory. High-frequency monitoring of households. Available online: http://documents1.worldbank.org/curated/en/115001604470985121/pdf/Indonesia-COVID-19-Observatory-High-Frequency-Monitoring-of-Households-Summary-of-Results-from-Survey-Round-One.pdf (accessed on 17 December 2020).
55. Ministry of Finance. Kerangka Ekonomi Makro dan Pokok-Pokok Kebijakan Fiskal Tahun 2021: Percepatan Pemulihan Ekonomi dan Penguatan Reformasi. Available online: https://fiskal.kemenkeu.go.id/publikasi/kem-ppkf (accessed on 13 October 2020).
56. Center for Indonesian Policy Studies (CIPS). Addressing Distance Learning Barriers in Indonesia Amid the COVID-19 Pandemic. Available online: https://c95e5d29-0df6-4d6f-8801-1d6926c32107.usrfiles.com/ugd/c95e5d_7710ed6e0a8e4aabb603711d8e5c7587.pdf (accessed on 25 November 2020).
57. Radhitya, T.V.; Nurwati, N.; Irfan, M. Dampak Pandemi Covid-19 Terhadap Kekerasan Dalam Rumah Tangga. *J. Kolaborasi Resolusi Konflik* **2020**, *2*, 111–119.

58. Ministry of Energy and Mineral Resource. Dampak Covid 19 pada Pengembangan Energi Terbarukan di Indonesia. Available online: http://iesr.or.id/wp-content/uploads/2020/04/Bahan-Vidcon-DJEBTKE-dengan-IESR-21-April-2020dek.pdf (accessed on 31 October 2020).
59. Sparrow, R.; Dartanto, T.; Hartwig, R. Indonesia under the New Normal: Challenges and the Way Ahead. *Bull. Indones. Econ. Stud.* **2020**, *56*, 269–299.
60. Prihartanto. Perkiraan of Medical Hazardous Waste Generation from Covid-19 Patient Handling Hospitals. *J. Sains Dan Teknol. Mitigasi Bencana* **2020**, *15*, 12–18.
61. United Nations. Shared Responsibility, Global Solidarity: Responding to the Socio-Economic Impacts of Covid-19. Available online: https://unsdg.un.org/resources/shared-responsibility-global-solidarity-responding-socio-economic-impacts-covid-19 (accessed on 13 October 2020).
62. Mongabay, 2020_Mongabay. COVID-19 No Excuse for Dropping Guard Against Illegal Fishing, Indonesia Says. Available online: https://news.mongabay.com/2020/05/covid-19-no-excuse-for-dropping-guard-against-illegal-fishing-indonesia-says/ (accessed on 4 November 2020).
63. Climate Home News. Forest Destruction Spiked in Indonesia during Coronavirus Lockdown. Available online: https://www.climatechangenews.com/2020/08/18/forest-destruction-spiked-indonesia-coronavirus-lockdown/ (accessed on 8 November 2020).
64. Save the Orangutan. Data Show Significantly Increased Deforestation Rates in Indonesia during Corona Lockdown. Available online: https://savetheorangutan.org/2020/10/16/data-show-significantly-increased-deforestation-rates-in-indonesia-during-corona-lockdown/ (accessed on 8 November 2020).
65. Forest Watch Indonesia. Potential Deforestation Post-COVID-19 Pandemic in Indonesia. Available online: https://fwi.or.id/wp-content/uploads/2020/12/Potential-Deforestation-Post-Covid-19-pandemic-in-Indonesia_pdf.pdf (accessed on 10 December 2020).
66. BAPPENAS. Kebijakan Nasional Dalam Pencapaian SDGs Pasca Pandemi. Available online: https://uclg-aspac.org/wp-content/uploads/2020/06/Kepala-Seknas-SDGs-Bappenas-Kebijakan-Nasional-dalam-Pencapaian-SDGs-Pasca-Pandemi.pdf (accessed on 13 October 2020).
67. The World Bank's Indonesia COVID-19 Observatory. Ex-ante Poverty & Distributional Impacts of COVID-19 in Indonesia. Available online: http://documents1.worldbank.org/curated/en/987911604465487663/pdf/Indonesia-COVID-19-Observatory-Ex-ante-Poverty-and-Distributional-Impacts-of-COVID-19-in-Indonesia.pdf (accessed on 30 December 2020).
68. The Jakarta Post. Almost All Business Sectors Will Get Tax Breaks: Govt. Available online: https://www.thejakartapost.com/news/2020/04/22/almost-all-business-sectors-will-get-tax-breaks-govt.html (accessed on 4 January 2021).
69. Ministry of Energy and Mineral Resource. Pemberian Stimulus Covid 19 Melalui Keringanan Tagihan Listrik. Available online: https://gatrik.esdm.go.id/assets/uploads/download_index/files/4fc73-200811-bahan-press-conference-11-agustus-2020-final.pdf (accessed on 31 October 2020).
70. Hadi, S.P.; Ibrahim, M.H.; Prabawani, B.; Hamdani, R.S. Environmental Dimension of Pandemic COVID-19: Case Studies of Indonesia. In *IOP Conference Series: Earth and Environmental Science* Semarang, Indonesia, 21 October 2020; IOP Publishing: Bristol, UK, 2020; Volume 623.
71. Greenpeace. Pemulihan Ekonomi Nasional: Business as Usual atau Pro-Lingkungan? Available online: https://www.greenpeace.org/static/planet4-indonesia-stateless/2020/09/1c781e50-briefing-paper-pemulihan-ekonomi-nasional-business-as-usual-atau-pro-lingkungan.pdf (accessed on 27 December 2020).
72. UNODC Southeast Asia and Pacific. COVID-19 Emergency Packages in Southeast Asia: An Overview and Analysis of Fraud and Corruption Risks. Available online: https://www.unodc.org/southeastasiaandpacific/en/what-we-do/anti-corruption/topics/covid-19.html (accessed on 2 January 2021).
73. Antara News. Peneliti Ingatkan Stimulus Fiskal Harus Efektif Atasi Dampak COVID-19. Available online: https://www.antaranews.com/berita/1371414/peneliti-ingatkan-stimulus-fiskal-harus-efektif-atasi-dampak-covid-19 (accessed on 1 January 2021).

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ARTICLE

New Realization of Disaster Risk Reduction Education in the Context of a Global Pandemic: Lessons from Japan

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Abstract The global COVID-19 pandemic has challenged different development sectors, including education. In this article, two main analyses are provided: one on the biological hazards of the pandemic in the context of the Sendai Framework for Disaster Risk Reduction 2015−2030, which analyzes the overall impacts on the education sector. Then we discuss the overall impact on education sectors, with specific focus on disaster risk reduction (DRR) education and education for sustainable development (ESD). Disaster risk reduction education and ESD are analyzed from the perspective of school-community-family linkages. Specific case analysis of COVID-19 response in the education sector is presented from Omuta City, Japan, which is considered as a champion city for ESD. Four phases of response in Omuta City are characterized with three specific foci: (1) mitigating covid impacts on educational program and participants; (2) preventing exacerbation of covid transmission within and outside schools; and (3) maintaining educational program integrity despite covid. Key lessons are summarized in the concluding section, which explore the importance of (1) educational governance (on critical decision making) during the pandemic as well as with cascading risks; (2) enhancement of school-community-family linkages as pandemic response commonalities between ESD and DRR education; (3) risk communication and citizen behavior; and (4) use of technology. We argue that integration of health and DRR education is important, that resilience needs to be redefined in terms of sustainable development goals (SDGs), and that education plays a vital role in achieving these ends.

Keywords Citizen behavior · Disaster risk reduction education · Education for sustainable development · Global COVID-19 pandemic · Japan · School-community-family linkage

1 Introduction

Disaster risk reduction (DRR) has evolved over time through the painful experiences of different disasters, both in Japan and abroad. Living with a diverse society and coexistence with nature has been part of human history. In our ever-changing lifestyles, we have termed the co-existence as education for sustainable development (ESD) or environment education. Similarly, living with disasters and living with risk have always been part of human history, and experiential learning has been the core to educational process. We have renamed this experiential process as disaster risk reduction education, henceforth called DRR education. As many authors have argued (Shiwaku and Shaw 2008; Shaw, Takeuchi, et al. 2011; Shaw, Shiwaku, et al. 2011; Thi et al. 2012; Shiwaku et al. 2016), DRR education links school, community, and home. The ultimate goal of DRR education is to internalize risk perception and enhance preventive/preparedness actions. This has always been an evolving process. Shaw, Takeuchi, et al.

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(2009) proposed the KIDA (Knowledge Interest Desire Action) model as the example of process-based DRR education.

School safety has been a strong pillar of DRR education, which includes a physical part, management components, and education components (ASEAN 2016; UNISDR and Global Alliance for Disaster Risk Reduction and Resilience in the Education Sector 2017). Japan has been in the forefront of DRR education, be it in the formal sectors like schools or informal sectors such as communities. After the 2011 Great East Japan Earthquake and Tsunami, the Japanese government has started focusing on DRR education related to the importance of life. It is often said that DRR education is a lifelong education and is focused on behavioral changes (UNICEF and UNESCO 2009; Shaw and Oikawa 2014). In DRR education, the traditional focus has been on "how to evacuate" as exemplified in emergency drills. But several disasters have taught the authors that it is not just sufficient to have an education on "how to." Rather, we need to focus more on "what to." In that more proactive space, risk information, risk understanding, and risk perception have a critical role to play. We need to think of a more holistic perspective within which to encourage resilience in the human, natural, and socioeconomic/governance systems.

The COVID-19 pandemic is the worst biological hazard-induced disaster observed in recent memory. Its unprecedented speed and spread have affected most parts of the world. The year 2020, which was supposed to be an important milestone year for the Sustainable Development Goals (SDGs) (UN 2015), the Sendai Framework for Disaster Risk Reduction 2015−2030, and the Paris Climate Agreement, is now under the shadow of the pandemic. The pandemic has not only impacted economies at every level, but it has also hindered the achievement of the SDGs. Moreover, the cumulative effect of COVID-19 has strongly impacted national and local development. The education sector is no exception to that adverse result. In the formal education sector, all levels, including primary, secondary, and tertiary (higher education), are affected. COVID-19 has also negatively influenced nonformal and informal education through lock downs or emergency regulation announcements in most countries, and thereby prohibited direct contact between people.

The United Nations, in a recent estimate, has pointed out that the pandemic has potentially affected 1.6 billion learners worldwide, impacting 94% of the student population (UN 2020). The impact is more prominent in poor and vulnerable communities, although several developed countries have also felt the disruption with a certain amount of increased dropout rate in the schools. Educational disruptions have impacted the mid-day, in school meal, which is often considered to be the only nutritious food for school-age children in poor neighborhoods. The prolonged pandemic has also increased violence against children, especially girls. Financing education seems to be a challenge in many countries, and gaps with pre-COVID-19 education funding are increasing with a staggering estimated figure of USD 148 billion globally as per the United Nations (UN 2020) report. This report also advocated establishing resilient education systems that can be linked to sustainable development of communities and nations.

The past few months of pandemic experiences have not only changed the course of education as a whole, they have also impacted the meaning and realization of DRR education. Cascading disasters have been common in many parts of the world. We have seen several cyclonic storms hit coastal communities in which the ongoing pandemic has posed a key challenge to the evacuation process. Strong heat waves and flooding during the pandemic have posed new health-related challenges. In many countries, education related to the pandemic is considered as a "health education." The pandemic impact goes beyond health, however, and is strongly related to the Sendai Framework for Disaster Risk Reduction 2015−2030 (Djlante et al. 2020; Shaw, Kim et al. 2020).

Within this context, this article analyzes the biological hazards perspectives of the Sendai Framework and draws a few key lessons. An analysis of DRR education in the new risk landscape follows, as well as analysis of ESD, DRR education, and the link to SDGs. Key issues of DRR education and COVID-19 impacts in Japan are also described. A specific case from Japan illustrates the need for anew realization of DRR education, linked to education for sustainable development. Finally, the article proposes key learning for DRR education in the "new normal" condition by analyzing the case of Omuta City, Japan. In this article, we argue that the new perspective of integrated DRR education can implement the lessons learned from the pandemic as well as enhance reduction of systemic, cascading risks.

2 Biological Hazards and Impacts on Education Sectors

The Sendai Framework reinforces the scope of disaster risk management by expanding beyond natural hazards to include biological hazards such as epidemic and pandemic diseases. The Sendai Framework also places strong emphasis on the need to build resilient health systems through the integration of disaster risk management into the provision of healthcare at all levels and, in particular, "to enhance cooperation between health authorities and other relevant stakeholders to strengthen country capacity for disaster risk management for health" (UNISDR 2015, p. 19). The purpose of this section is to highlight that a pandemic response is not just a health response, but rather is an integrated development sector's response to a disaster, which is caused by biological hazards.

United Nations Office for Disaster Risk Reduction (UNDRR) terminology defines biological hazards as follow (UNDRR 2017a, 2017b):

> Biological hazards are of organic origin or conveyed by biological vectors, including pathogenic microorganisms, toxins and bioactive substances. Examples are bacteria, viruses or parasites, as well as venomous wildlife and insects, poisonous plants and mosquitoes carrying disease-causing agents.

In a recent study, Shaw, Chatterjee, et al. (2020a, 2020b) have identified 10 basic principles that need to be incorporated into future risk preparedness (Fig. 1). These principles define the key aspects of biological hazards: (1) risk assessment (integrated surveillance and early detection, identification of hotspots/clusters); (2) risk planning (multidisciplinary science-based support, worst case scenario planning); (3) recovery planning (with regional collaboration); and (4) use of technologies and stakeholder participation in order to address fake news and infodemics (information as the key of epidemic, mentioned by WHO Director General in January 2020) by means of information sharing, which is an important component of risk communication. Risk communication is also an essential element of disaster risk management (DRM) because it shapes people's perceptions of risk and influences their actions with respect to disaster preparedness and disaster response. Priority Four of the Sendai Framework (UNISDR 2015) specifies the importance of investing in disaster risk communication along with multi-hazard forecasting and early warning systems, developing these systems with participatory process, tailoring them to the needs of users, and broadening release channels for disaster early warning information. These principles can be adopted for the disaster risk reduction process, and the education sector can also learn and adopt some of these goals and practices.

The education sector is differentially affected by COVID-19. The sector needs to provide a unified response with: (1) mitigating disease impacts on students, staff, and support personnel within its direct purview; (2) adopting practices that do not exacerbate disease transmission in the local community; and (3) maintaining its educational mission in creative and innovative ways, despite being seriously impacted, based on its unique knowledge resources. The education sector can help reduce local impacts by generating health education that increases student and community awareness of disease ecology and preventive public health practices. In this way the education sector plays a critical role in risk communication about outbreaks, epidemics, and pandemics.

Education also supports development of rich human resources by imparting required training and skills. Higher education institutions (HEIs) are resourceful in conducting research on various aspects linked to an outbreak and in increasing risk awareness. During the COVID-19 outbreak, the HEIs can play an important role in response to the disease outbreak, spread, and status. This has been highlighted by examples such as the role of Johns Hopkins University in developing an online dashboard that documents the spread of the infection or the role played by students at the Indian Institute of Technology, Roorkee in developing low-cost ventilators (Izumi et al. 2020).

The education sector is one of the most frequently impacted service sectors. The main reason is the closure of schools and absenteeism of teachers. The propensity of children to become infected with particular virus infections has led to the closure of schools in the past. This disturbs the academic calendar and adds stress to parents and students alike. The education sector has embraced online tools, redefining how learning takes place by opening up the traditional classroom. The effectiveness of online education in student learning and its impact on care providers' regular responsibilities (for example, work duties

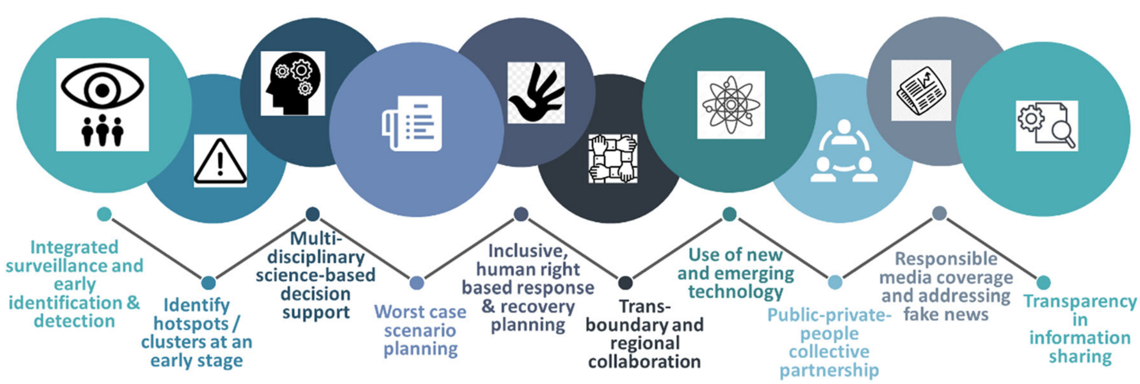

Fig. 1 Basic steps and learning for biological hazard integration into disaster risk reduction (DRR). *Source* Shaw, Chatterjee, et al. (2020a)

and care responsibilities) should not be neglected. Issues of undernutrition in low income groups in developing countries and obesity globally not only put the children at high risk of infection but also may expose them to long-term developmental, psychological, physical, and emotional complications (Dunn et al. 2020). A pandemic may expose children to higher risks of abuse, neglect, and other issues around child protection (UNICEF 2020). A biological hazard also may often be an opportunity for higher education institutions and research organizations to engage in developing new tools, encourage research and innovation, and find new funding opportunities.

3 Disaster Education in the New Risk Landscape

COVID-19 has brought new challenges as well as opportunities in the education sector, similar to other sectors like health, livelihoods, and so on. In the new risk landscape, where the biological hazards continue over a period of time, and there are risks of cascading hazards, education sector's role becomes more important for formal, informal, and nonformal education.

3.1 Implication of COVID-19 Pandemic to Education

Early resumption and continuity of educational services after a disaster is listed as one of the global targets in the Sendai Framework for Disaster Risk Reduction 2015–2030. The COVID-19 pandemic gave enormous global shocks to children's education. Different from a natural hazard and disaster, the pandemic affects children's education all over the world almost simultaneously. The impact of educational services disruption by the COVID-19 pandemic extends from lost learning opportunities to children's learning outcomes, increasing dropouts, and disruption of school nutrition programs. Isolation of children from schools could also affect their mental health. In addition, economic shock puts pressures on households that could decrease educational expenses. Fiscal pressure may lead to reduction in education investments, impacting learning environments and quality of education (World Bank 2020; UN 2020).

With the COVID-19 virus pandemic, each country has taken all possible actions to prevent disease spread, and international cooperation has been explored to overcome the crisis. Lockdown measures were utilized in cities in many countries. In mid-June of 2020, lockdowns started to be lifted gradually in some countries although the spread of the coronavirus and emergence of new varieties continue. New lockdowns were imposed in many countries, which were undergoing a third wave between November and December 2020. In Japan, schools were faced with sudden closures in the beginning of March and then again in June 2020, just as the country was at the phase of safe school resumption. Although people tried to return to their normal daily life, it was not possible to resume the same life as before the pandemic. To turn the COVID-19 pandemic crisis into opportunities in the education sector, the international community started to discuss how educational systems could be built back stronger and more equitable than before (UN 2020; World Bank 2020). Since disaster education is one of learning activities, it is worthwhile examining what disaster risk reduction education could learn from the COVID-19 pandemic in the new risk landscape.

3.2 Living with COVID-19 Risk

Risk communication has been playing a vital role in management of the COVID-19 pandemic. Governments and public health agencies in each country have been informing the public about what the COVID-19 virus is, what the symptoms of the virus are, how to avoid catching the virus, what measures to take when the suspicion of infection arises, and so on. Public health education also involves multiple messages, not strictly about risk, that express concerns, opinions, or reactions to risk messages or to legal and institutional arrangements for risk management (Natural Research Council 1989). The goals of risk communication in public health are to share information vital for saving life, protecting health, and minimizing harm to self and others throughout a society. Regarding the COVID-19 virus, each individual needs to change their behavior to avoid personal risk of infection, but also the whole society needs to take actions against societal risk to prevent disease spread in the society. To respond to a societal risk requires all citizens, each of whom has a different level of risk perception, to participate in discussions to reach a social agreement on appropriate response to a societal risk. Risk communication is recognized as multidirectional communication and engagement with affected populations so that they can take informed decisions to protect themselves and their loved ones. This can and should utilize the most appropriate and trusted of channels of communication and engagement (WHO 2014). It could be said that infectious risk of COVID-19 is a new risk, which people perceive as "dread" and "unknown." The higher the dread factor levels and the higher the perceived unknown risks, the more people want to see such current risks reduced, and the more they want to see strict regulation employed to achieve the desired reduction in risk (Slovic 1987).

4 Education for Sustainable Development, Disaster Risk Reduction Education, and Sustainable Development Goals

ESD, DRR education, and SDGs are inter-connected, and often considered as the part of the same coin. Oikawa (2016) has demonstrated the linkages among the three types of education, and the connectivity goes to the school community linkages. This section provides a brief overview of these three types of education process.

4.1 Improving Disaster Risk Reduction Education through Education for Sustainable Development

Faced with the global COVID-19 infection, social systems and lifestyles need to adjust to extreme change. Disaster risk reduction education should also change its concept and method towards achieving a sustainable society. Education for sustainable development brings new perspectives to DRR education. As a lesson learnt from the 2011 Great East Japan Earthquake and Tsunami and ESD practice in Kesennuma City, Miyagi Prefecture, Japan, ESD brought new innovations to DRR education from the perspective of the sustainable development concept. This achievement was attained by improving the quality of DRR education, fostering DRR ability and attitude, and building networks and partnerships for DRR (Oikawa 2014c). In the context of DRR and ESD values, such concepts as respect for lives, human security, life together (coexistence), and building a sustainable society (Build Back Better) emerged. Education for sustainable development also transforms learning styles of DRR education. Education for sustainable development recommends learning that is inquiry-based, problem-solving, experience-based, project-oriented, community-based, and integrated. Adoption of those ESD learning methods into DRR education should further improve the quality of DRR education. As a result, through the improvement based on ESD, DRR education can foster DRR abilities and attitudes that become the building blocks of disaster management (Oikawa 2014b).

4.2 Education Achieving the Sustainable Development Goals

Sustainable development goals ensure inclusive and equitable quality education and promote lifelong learning opportunities for all at Goal 4. Education is at the heart of the 2030 Agenda for Sustainable Development and is essential for the success of all SDGs (Fig. 2). Especially, ESD is a key enabler of all the other SDGs, so that the overall objective of ESD for 2030 is to build a more just and sustainable world through the achievement of the 17 SDGs. Pursuant to the achievement of SDGs, the United Nations Educational, Scientific and Cultural Organization (UNESCO) submitted a proposal for a framework, entitled Education for Sustainable Development: Towards Achieving the SDGs (ESD for 2030),[1] as a 10-year follow-up to the Global Action Programme on Education for Sustainable Development (2015–2019),[2] and this proposal was adopted at the UN General Assembly in December 2019. The ESD for 2030 therefore proposes to strengthen ESD's contribution to all SDGs, with particular focus on helping attain Goal 4. The UNESCO document also stresses that future education—the Education 2030 agenda—should place emphasis on the contribution of learning content to the survival and prosperity of humanity (UNESCO 2019). In this context, the COVID-19 pandemic is an unprecedented disaster that threatens human existence, and a common issue to be solved by all humans. Therefore, the response to prevent the COVID-19 pandemic should be implemented in the context of SDGs, and as result, its process leads to the achievement of SDGs. To realize this, education, especially DRR education based on ESD, should make a great contribution through capacity development.

4.3 Overview of Disaster Risk Reduction Education and Sustainable Development Goals

Sustainable development goals mention DRR at Goal 1, 11, and 13. In the SDGs context, it is possible to promote DRR education targeting DRR-related goals above, mainly Goal 11, and combining with SDG 4 focused on education. Yet DRR education should not be limited to SDGs 4 and 11. Disasters have serious impacts on other issues such as poverty (Goal 1), food and hunger (Goal 2), clean water and sanitation (Goal 6), energy (Goal 7), infrastructure (Goal 9), and so on. Many disasters, such as storm, flood, drought, tsunami, and landslide, occur from climate change (Goal 13), rising seawater temperature and tsunami (Goal 14), and deforestation and desertification (Goal 15). Therefore, promoting DRR education centered on DRR (Goal 11) and education (Goal 4) in relation to other goals can contribute to achieving all SDGs. The COVID-19 pandemic is also related to many other SDG goals, such as poverty, food, health, sanitation, economic growth, among others. Thus responses to prevention of infection are congruous with the aims of DRR education. This perspective is crucial for education of COVID-19 pandemic.

[1] https://en.unesco.org/news/esd-2030-whats-next-education-sustainable-development.

[2] https://www.mext.go.jp/unesco/004/1339970.htm.

Fig. 2 Education for sustainable development (ESD) towards achieving sustainable development goals (SDGs). *Source* Left: Japanese National Commission for UNESCO (https://www.unesco.emb-japan.go.jp/htm/jpcommissionunesco.htm); right: UNESCO (https://en.unesco.org/sustainabledevelopmentgoals)

5 Japan's Disaster Risk Reduction Education and COVID-19 Response

Disaster education is considered one of the components of safety education in Japan, which aims to promote a person's ability to overcome normalization bias that inhibits realistic disaster threat risk assessment, prediction, and avoidance, and thus makes it possible to take pragmatic, proactive action against a looming threat (MEXT 2019). Education for risk communication is scattered among environmental education, safety education, information education, and consumer education in the current national curricular guidelines in Japan. But the topic of natural hazards and disasters is still dealt with in the confines of individual subject areas. That is, the natural environment and the social environment are covered separately in science education and social studies education, respectively. Because of the different goals and characteristics of these two subject areas, natural hazards and disasters have not been comprehensively covered despite the need for a cross-curricular approach (Fujioka 2016).

To overcome the division in the curriculum, ESD is one of the solutions because integrated efforts in numerous connected fields are required to achieve the construction of a sustainable society. Experiential learning is also a useful approach for children to learn about a concept of risk and risk management that is difficult even for the adults to understand. Since the scale and degree of a disaster could be different according to the natural and social vulnerabilities of each affected area, a place-based experiential learning could be an effective approach. Disaster education is not only limited to formal education. Extracurricular and continuous education activities in communities could help the participants, regardless of their age, to build trustful relationships among themselves, and to understand their own community's society and nature holistically. These educational efforts could energize participatory disaster risk management by any local community trying to find, through discussion, solutions that reduce disaster risk.

From the experience of the 2011 Great East Japan Earthquake and Tsunami disaster, participatory disaster risk management by the local community has been proven to be an effective way of communicating risk. When a local community was involved in planning for disaster preparedness, and people took ownership of their own safety plans, they were better prepared and better able to take the necessary actions to protect themselves. Successful risk communication occurs when there is holistic learning, facilitation, and trust. In contrast, risk communication in the Fukushima nuclear accident was regarded as a case of failure in terms of the timing of information released, the accuracy and details of the information provided, and the trust and credibility of the information sources cited (Shaw 2012).

Having only basic or minimum understanding of risk, how did people respond to the COVID-19 risk in the case of Japan? Risk perception is different in each country based on the society's culture and the government's actions. During a state of emergency period, the Japanese people obeyed the stay-home request without any law enforcement (Shaw, Kim et al. 2020). Commuting by jam-packed trains is a notorious daily-life scene in Tokyo, but empty seats were found in commuter trains after repeated requests from the government to reduce the number of people in public place by 80% compared to before the state of emergency declaration. People kept social distances, wore masks in public spaces, and washed hands and gargled when they returned home (Tashiro and Shaw 2020). Not only did individual behavior change to avoid infectious risk, people also refrained from becoming spreaders of the coronavirus. In this short period, the Japanese people and society experienced first-hand the behavioral changes needed to avoid COVID-19 risk. But discrimination and stigma against hospital workers and hoarding certain products also occurred in the society; these behaviors were assumed to be caused by fear of contamination and rumors about potential shortages potentially caused by the unknown and the invisible coronavirus.

6 Case of Omuta City

Omuta City in Fukuoka Prefecture has taken deep interest and leadership in promoting ESD through SDG activities. Working closely with the schools, local communities, academics, and nongovernment organizations, as well as business sector, the city has established a collaboration scheme for DRR, ESD, and SDG.

6.1 Building the Linkage of School and Community through Education for Sustainable Development and Sustainable Development Goals

The Omuta City case is analyzed as a good example of school and community linkage practiced through ESD. Omuta City is located in the southeast of Fukuoka Prefecture, adjacent to the Ariake Sea and close to the Kumamoto Prefecture boundary. Omuta's economy flourished along with the coal industry as long as coal was Japan's primary fuel source. But in 1997, faced with competition from alternative fuel sources, the Miike Coal Mines closed, Omuta's industry declined, and population fell by nearly 50% as the city's work force sought jobs elsewhere. Today, utilizing the coal mine-related resources, which are World Heritage sites, Omuta is advancing its own Omuta-brand SDGs to enhance education that promotes sustainable communities. With the slogan "Omuta, an UNESCO Associated School Town," all of the city's 30 elementary schools, junior high schools, and special needs schools became UNESCO Associated Schools (ASPnet School) in 2011 and has been practicing ESD. The Omuta City Board of Education (BOE) has built an ESD Consortium comprising local companies, nongovernment/nonprofit organizations, the University of Teacher Education Fukuoka, and others. Through building the ESD Consortium, the linkage of school and community in Omuta City has been strengthened (Oikawa 2016). In 2018, the city developed "Omuta version SDGs" by adapting UN SDGs to align with local issues. The consortium selected several sustainable development goals and clarified those children's competencies to be nurtured to achieve the goals based on former ESD practices (Fig. 3). Schools in the city also promote DRR education utilizing their linkage with local communities (Omuta BOE 2018).

6.2 Educational Response to COVID-19 in Omuta City

The Omuta City Board of Education (BOE) has been conducting responses to COVID-19 infection by collaborating with schools, parents, and local communities since the COVID-19 pandemic occurred in Japan. Omuta City has been learning the lessons of the 2011 Great East Japan Earthquake and Tsunami in Kesennuma City, such as the disaster management and recovery process (Oikawa 2012). Omuta BOE made the best use of appropriate ESD experiences and established links with communities and institutions to make response plans to COVID-19 and to implement them effectively. Under the threat of a spreading COVID-19 infection in Fukuoka Prefecture, Omuta BOE was required to make quick decisions about principles of and action plans for response, direction to schools, and information to parents and citizens. Based on accumulated educational and ESD experience, BOE has implemented continuous responses to prevent COVID-19 from spreading. These plans are adjusted according to the current situation and phase of infection.

6.2.1 *Phase 1: Japanese government Request for school closure (1 March–6 April 2020)*

On 28 February 2020, following the spread of COVID-19 in Japan, the Japanese government requested that all schools in Japan close beginning on 1 March. In a few days, all schools and boards of education in Japan were required to prepare for school closure, to take care of students, and to respond to COVID-19 infections. The Omuta BOE also made some response plans to COVID-19 by communicating and collaborating with school principals and teachers. The BOE held urgent principal meetings many times to discuss preparedness and responses to the pandemic. It conducted planning and implementing responses by utilizing the knowledge and experience in ESD, and it also modified the response of each school while respecting their initiatives.

In response to specific requests at school, teachers visited students' homes for health checks while schools were closed. The BOE also promoted collaboration with the social welfare section of the city office to support students who needed special assistance, starting a week after school closure. Concretely, Omuta BOE proposed cooperation with the Council of Social Welfare to supply food (lunch

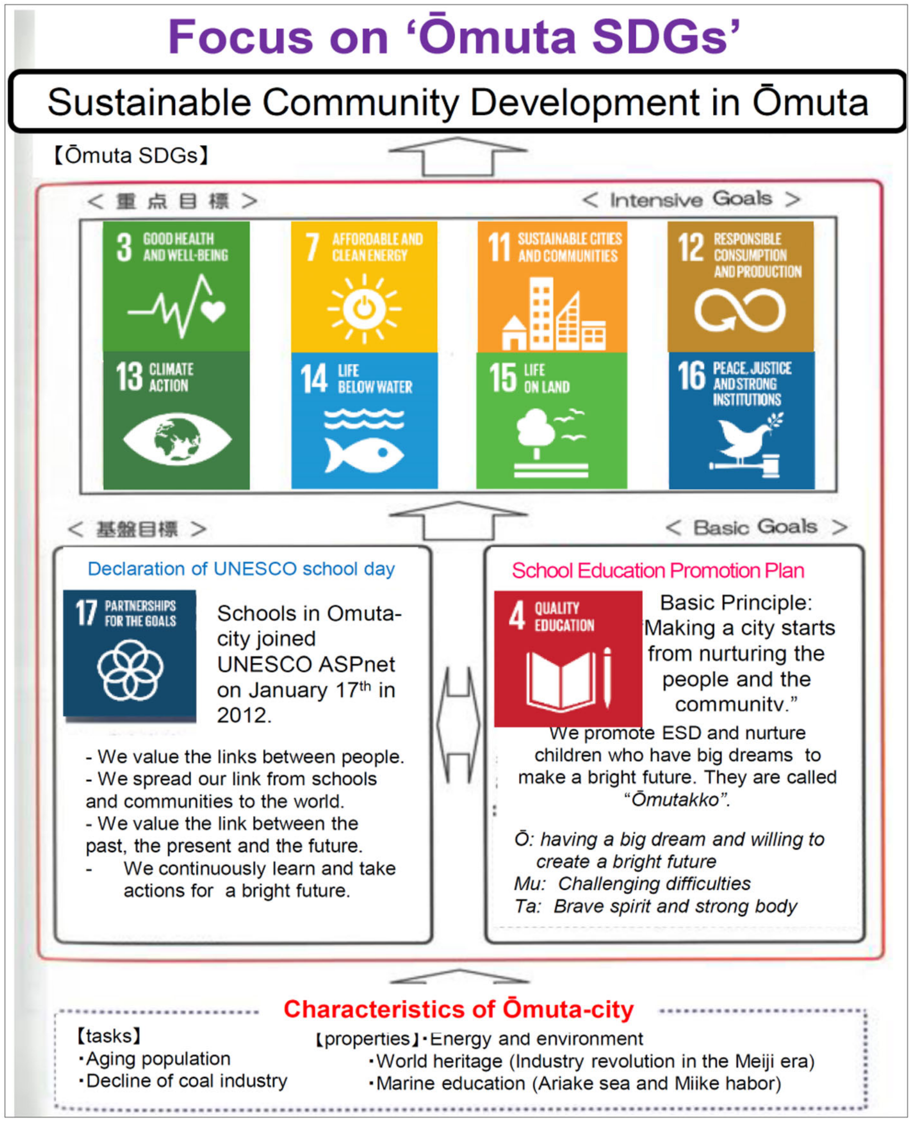

Fig. 3 Omuta version sustainable development goals (SDGs). *Source* Omuta City (https://omutacityzoo.org/sdgs)

box) for underprivileged children during school closure. The BOE and teachers of each school delivered these lunch boxes to students of low-income families. Also the BOE required school principals to invite at-risk students, who might be exposed to child abuse risks in their families, to come to their schools to collect their lunch box in order to check on their lives at home.

In addition, the BOE negotiated with welfare facilities to accept handicapped students while special support schools were closed; the BOE also ordered schools to take care of students of double-income or single-parent families until those children could return to after-school day-care centers, because daytime working parents are unable to provide supervision while children are home. As a further monitoring action, the Omuta BOE dispatched school social workers to low-income households and families with a child abuse history. This initiative created an opportunity to research children's meal or health situations, and to provide lifestyle support during school closure. Throughout the response, the BOE received advice from specialists, such as a doctor in the public health center, on the best practices available to avoid COVID-19 outbreaks at schools.

6.2.2 Phase 2: Declaration of a state of emergency (7 April–14 May 2020)

On 7 April 2020, a state of COVID-19 emergency was declared in Fukuoka Prefecture. Concern about the COVID-19 pandemic was increasing among parents and citizens, because some COVID-19 infected persons were also found in Omuta City. Schools had to shift the method of contact with students from in-person home visits to indirect communication, such as letters or emails, to prevent the spread of the new coronavirus infection. Omuta also directed the curriculum coordinators of each school to reorganize a new school curriculum that could make up for lost learning time because of school closure and adjust to the new school education setting of the post-corona infection period. All the schools reorganized their curriculum and lesson plans by selecting nonacademic school events—such as sports day or culture day—to provide enough lesson hours to learn the reconfigured school curriculum even if the school year was shortened due to school closure.

6.2.3 Phase 3: Post declaration of a state of emergency (14–31May 2020)

The emergency declaration in Fukuoka Prefecture was lifted on 14 May 2020. Because COVID-14 was calming down day by day, the BOE could target the day of school restart and schools had to prepare for reopening school. Omuta BOE considered the plan of "distributed school day"[3] and implemented on 18 May a two week period as a step to "simultaneous school attendance." On the other hand, on 8 May the BOE decided to shorten summer vacation from 40 to 11 days to recover the delay of learning due to corona infection. Those are very quick responses and decisions. Through a clear decision-making process, which involved consultation with not only teachers but also students and parents, the Omuta BOE was able to build support for an in-person school restart and alleviate concerns about the restructured school education and schedule.

6.2.4 Phase 4: School reopening (1 June 2020 onward)

On 1 June 2020, all the schools in Omuta City restarted in-school lessons all at once. In reopening school, each school reconfirmed that ensuring students' security and safety was the priority of school education. All schools planned to resume school on the premise that corona infection could be prevented. School teachers did their best to build a better environment and lifestyle at each school and classroom to prevent corona infection. For example, practical actions included enforcement of wearing a mask, temperature measurement and gargling, hand washing, disinfection, keeping social distance, improved ventilation, and so on.

Since reopening, new issues have emerged regarding disaster risk reduction at school. In almost all the schools, gymnasiums are designated as evacuation shelters, but they get crowded with evacuees whenever a disaster occurs. Under these conditions, the risk of corona infection inevitably will increase in evacuation shelters from any disaster, so evacuees must maintain social distance even in the shelters. Every municipality, including Omuta City, must find and reserve other evacuation spaces or shelters to supplement school space to prepare for a future disaster, which could occur soon and coincide with a corona virus outbreak. That is a new and common problem for disaster risk reduction to solve during the period of COVID-19.

6.3 Key Learning from Omuta City

The three key issues of pandemic response in the education sector can be reflected through: (1) mitigating the disease impacts on the education sector; (2) preventing increased disease transmission by the education community; and (3) preventing impacts on the education sector from disrupting its educational mission. Table 1 shows key lessons from the Omuta case in these three key pillars of response undertaken by the education sector.

A few general lessons emerged from the Omuta City case study can be summarized concisely and also applied in similar conditions when coping with future biological and related cascading hazards:

(1) Share information about the COVID-19 pandemic exactly and quickly with the mayor, board members, city council, schools, teachers, students, and parents;
(2) Promote principles and policies of the educational response to the prevention of corona virus infection as soon as possible;
(3) Clarify the division of roles of BOE, principals, teachers, and parents;
(4) Visualize the decision-making process to field based responses;
(5) Introduce the knowledge and advice of epidemiology specialists into decision-making and establish rigorous response processes to maximize prevention of corona infection; and
(6) Create a proactive planning and response process that is mutually supportive of and compatible with disaster risk reduction management

7 Discussion

The new realization of DRR education lies in the response to new types of hazard such as biological hazards. Although the Sendai Framework has expanded the scope of hazards to biological hazards, NaTech (natural hazard induced technological disaster), and so on, this is the first time in recent history that we have faced such a prolonged biological hazard in terms of pandemic, which has affected

[3] This means that students are grouped in different sections, and were asked to come to school alternate days to avoid the concentration of people in one place.

Table 1 Key lessons from COVID-19 responses in the education sector of Omuta City

	Mitigating the Impact	Preventing Exacerbation of Transmission	Maintaining Mission Despite Impacts
Phase 1 (Early stage)	Educational governance with school leadership and Board of Education is critical	Specialist advice and science-based decision making is important	Collaboration with other sectors such as social welfare is important
Phase 2 (Emergency stage)	Reorganization of syllabus/curriculum to cover any delay in education delivery is effective	Shifting to online communication instead of direct home visits is found effective	Cancel school events to increase lesson hours enough to enhance learning even in a shortened school year
Phase 3 (Post emergency stage)	Target the day of school restart, and build support of and confidence in Parent and Teacher Association with online discussion	Undertake precaution measures using innovative technologies, like facial temperature check, health check, physical distancing, and so on	Shorten summer vacation to recover lost in-class learning options due to COVID-19 induced school closures
Phase 4 (Recovery stage)	Ensure students security and safety is a priority of school education, including reduced impacts of cascading hazard	Build better environment and lifestyle of school to prevent corona infection	Reserve alternate spaces and shelters to keep social distance for evacuation

different parts of global society. Cascading disasters like typhoons, floods, and heat waves also have been prominent during the global pandemic in Japan as well as elsewhere. In a recent report, Das et al. (2020) discussed evacuation and shelter management challenges during floods in west Japan amidst the pandemic. Usually the schools become evacuation shelters during disasters in Japan, which created critical challenges of shelter management during the COVID-19 outbreak. In 2020, people did not evacuate to schools in many cases, mainly due to fear of infection and a desire not to affect the education continuity (because most of school classes are already affected due to pandemic). Where people have evacuated into the schools—mostly abandoned school buildings in rural and semirural areas in Kumamoto Prefecture—shelter management was a key challenge due to the new government guideline of 60% occupancy of the shelter to maintain safe physical distancing. Also, a strict health monitoring mechanism was imposed, and the entry of volunteers was restricted. The lessons from cascading disasters, as compiled by Das et al. (2020), will be useful for future school operation during time of emergency. New learning of DRR education can be summarized below in terms of (1) governance and decision making; (2) school-community-family linkages; (3) risk communication and citizen behavior; and (4) use of technology.

Educational governance becomes very critical during as well as after pandemic decision making, where crucial decisions on the opening of schools and maintenance of appropriate social behavior inside and outside school (during commuting) become important. All three aspects of educational governance (structural, nonstructural, and functional) issues become crucial. In many countries COVID-19 related education is primarily categorized under health and sanitation education for washing hands taking proper care of health issues, and so on. But a proper integration into DRR education is desirable. Also, linkage of the Board of Education with the Social Welfare department helped in addressing the issues of the vulnerable children.

The connection between school and community, including families, is very critical for promoting DRR education. As a lesson of the 2011 Great East Japan Earthquake and Tsunami, it was reported that disaster management, including evacuation and management of shelter, was remarkably successful in those schools that have good linkages and collaborations with their communities and outside institutions through high quality DRR education within the community (Oikawa 2013). From the case of Omuta City, significant commonalities with school responses and education to prevent disease spread during the COVID-19 pandemic can be observed. The school is not able to prevent the spread of corona infection without cooperation with community and family, because the school had to close for a while and to entrust students to their families and communities as the COVID-19 virus rapidly diffused globally and locally. In Japan, the linkage of school and community must be built through collaborative school activities or joint projects with community. The Parent and Teacher Association (PTA), working in a collaborative system with the local community, was able to achieve broad support for a Community School. Education for sustainable development embraces all of these initiatives and it also contributes to create a sustainable society and community; this is the best approach and method to build linkages and community engagement (Oikawa 2014a). Thus, the key essence of ESD and DRR education as school community linkage is reestablished through the lessons from pandemic responses, and this leads to achievement of sustainable development goals and emergence of a more resilient society and community.

Risk communication becomes an important factor, and schools can play a vital role by enhancing risk communication (Shaw et al. 2014). For DRR education, providing appropriate information through schools to community and family is effective. In case of pandemic response also, it was found an effective mechanism to provide the right and trusted information. A pandemic is an invisible disaster, correct information from a trusted source is crucial, and schools have played important roles in information dissemination. Behavioral changes and being responsible citizens are of utmost importance, which is linked to school and community collective education (Shaw, Kim, et al. 2020).

Finally, COVID-19 has seen the use of different types of innovative technologies in all sectors, including education. Several innovative ways to provide online classes and online classrooms were used to deliver lectures and maintain teacher and student contact. Health surveillance using a thermal camera was common in most of the schools. Different apps were used extensively for contact tracing in many schools and education sectors. All these technologies have implications for DRR education as well, which can also be used for education continuity through online classes (when schools are used as evacuation shelter after a disaster) or safety notification after a disaster through health related apps, as well as regular health checks, and so on.

What could be the implication of the COVID-19 experience to disaster education? There is an urgent need for a conversion about disaster prevention education that promotes a true disaster risk reduction and resilience education in the new risk landscape. Focusing on the Sendai Framework priority, understanding that risk includes all its dimensions of vulnerability, capacity, exposure of persons and assets, hazard characteristics, and the environment. This holistic approach needs to be included in risk reduction and resilience education (UNDRR 2017a). The current concept of single hazard DRR education also needs to be changed. We are increasingly facing cascading hazards and complex emergencies with different levels of uncertainties. Thus, traditional DRR education is significantly challenged and we need new cycles of learning for holistic DRR and resilience education. Risk communication for complex emergencies, capacity enhancement, and resilience building are some important key issues.

8 Conclusion

The Sendai Framework has expanded the scope of hazards, and thus DRR education needs to incorporate new learning from COVID-19 responses in the education sector. Cascading risks also become a crucial factor in the prolonged timeframe of a global pandemic. COVID-19 has seriously affected the education sector, and its responses are also varied based on each country's governance structure. The case of Japan presented here has drawn the lessons from the evolution of DRR education, previous learning from the 2011 East Japan Earthquake and Tsunami, and the current pandemic. The experience of Omuta City, which is a champion city of ESD, shows that SDGs are attainable as a part of a holistic strategy and that governance plays a critical role in education in emergencies. Informed and science-based decision making by the Board of Education and schools are critical both in the pandemic as well as in DRR education. School-community-family linkages, risk communication, and responsible citizen behavior are key variables to reduce the impacts of the pandemic disaster and can be adapted to other disaster risk management needs. Technology has played a critical role in the COVID-19 pandemic, which can also be used in future DRR education. New realization of DRR education lies in the fact that it offers an essential lens through which to understand a complex emergency with cascading risks and differential levels of uncertainties. Also, health education and DRR education have complementarities, but still need to promote more synergies. Decision making and risk communication for complex emergencies needs to be incorporated in DRR education, so that it becomes a comprehensive risk reduction and resilience education, leading to a safer and sustainable society and community.

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References

ASEAN (Association of Southeast Asian Nations). 2016. ASEAN common framework of comprehensive school safety. https://aseansafeschoolsinitiative.org/asean-common-framework-for-comprehensive-school-safety/. Accessed 20 Jun 2020.

Das, S., R. Shaw, S. Kanbara, M. Abe, and T. Komino. 2020. *Cascading disaster: Lessons from South Japan Flood Amidst Pandemic 2020*. Tokyo, Japan: CWS Japan.

Djlante, R., R. Shaw, and A. DeWit. 2020. Building resilience against biological hazards and pandemics: COVID-19 and its implications for the Sendai Framework. *Progress in Disaster Science* 6: Article 100080.

Dunn, C.G., E. Kenny, S.E. Fleischhacker, and S.N. Bleich. 2020. Feeding low-income children during the COVID-19 pandemic. *The New England Journal of Medicine* 382 (18): Article e40.

Fujioka, T. 2016. Disaster prevention education in the Japanese school curricula in recent years: Current status and future challenges. In *Disaster resilience of education systems: Experiences from Japan*, ed. K. Shiwaku, A. Sakurai, and R. Shaw, 39–52. Tokyo, Japan: Springer.

Izumi, T., V. Sukhwani, A. Surjan, and R. Shaw. 2020. Managing and responding to pandemics in higher educational institutions: Initial learning from COVID-19. *International Journal of Disaster Resilience in the Built Environment* 12(1): 51–66.

MEXT (Ministry of Education, Culture, Sports, Science and Technology). 2019. Reference material on school safety: Safety education at school for fostering "zest for living". https://www.mext.go.jp/component/a_menu/education/detail/__icsFiles/afieldfile/2019/04/03/1289314_02.pdf. Accessed 20 Jun 2020 (in Japanese).

Natural Research Council. 1989. *Improving risk communication*. Washington, DC: National Academies Press. https://pubmed.ncbi.nlm.nih.gov/25032320/. Accessed 20 Jun 2020.

Oikawa, Y. 2012. Education for sustainable development and its implications to recovery process in Kesennuma. In *East Japan Earthquake and Tsunami: Evacuation, communication, education, volunteerism*, ed. R. Shaw, and Y. Takeuchi, 165–186. Singapore: Research Publishing.

Oikawa, Y. 2013. Institutional response in education sector in Kesennuma City. In *Disaster recovery: Used or misused developing opportunity*, ed. R. Shaw, 89–113. Tokyo, Japan: Springer.

Oikawa, Y. 2014. Education for sustainable development: Trends and practice. In *Education for sustainable development and disaster risk reduction*, ed. R. Shaw, and Y. Oikawa, 15–35. Tokyo, Japan: Springer.

Oikawa, Y. 2014. City level response: Linking ESD and DRR in Kesennuma. In *Education for sustainable development and disaster risk reduction*, ed. R. Shaw, and Y. Oikawa, 155–176. Tokyo, Japan: Springer.

Oikawa, Y. 2014. Educational governance issues in post tsunami responses in Kesennuma City, Japan. *Asian Journal of Environment and Disaster Management* 6(2): 153–173.

Oikawa, Y. 2016. International cooperation: ESD and DRR in Japan. In *Disaster resilience of education systems: Experiences from Japan*, ed. K. Shiwaku, A. Sakurai, and R. Shaw, 143–180. Tokyo, Japan: Springer.

Omuta BOE (Omuta City Board of Education). 2018. Omuta version SDGs (ver.1). http://www.e-net21.city.omuta.fukuoka.jp/consortium/images/2020/03.pdf. Accessed 15 Oct 2020 (in Japanese).

Shaw, R. 2012. *Community based disaster risk reduction*. Bingley, UK: Emerald.

Shaw, R., and Y. Oikawa. 2014. *Education for sustainable development*. Tokyo, Japan: Springer.

Shaw, R., R. Chatterjee, and A. Dabral. 2020a. Integrating biological hazards (including pandemics) into DRR planning. Technical Advisory Document. Geneva: UNDRR.

Shaw, R., R. Chatterjee, and A. Dabral. 2020b. Integrating biological hazards, including pandemics into DRR planning. Annex. Geneva: UNDRR.

Shaw, R., Y.K. Kim, and J. Hua. 2020. Governance, technology and citizen behavior in pandemic: Lessons from COVID-19 in East Asia. *Progress in Disaster Science* 6: Article 100090.

Shaw, R., K. Shiwaku, and Y. Takeuchi. 2011. *Disaster education*, vol 7. Community, environmental, and disaster risk management series. Bingley, UK: Emerald Group Publishing Limited.

Shaw, R., Y. Takeuchi, S. Matsuura, and K. Saito. 2014. Risk communication. In *Learning from megadisasters: Lessons from the Great East Japan Earthquake*, ed. F. Ranghieri, and M. Ishiwatari, 241–246. Washington, DC: The World Bank.

Shaw, R., Y. Takeuchi, and K. Shiwaku. 2011. '"Tsunagaru"': The essence of disaster education. In *Disaster education*, ed. R. Shaw, K. Shiwaku, and Y. Takeuchi, 153–162. Bingley, UK: Emerald Group Publishing Limited.

Shaw, R., Y. Takeuchi, K. Shiwaku, G. Fernandez, Q. Gwee, and B. Yang. 2009. *1-2-3 of disaster education*. Kyoto, Japan: Kyoto University.

Shiwaku, K., and R. Shaw. 2008. Proactive co-learning: A new paradigm in disaster education. *Disaster Prevention and Management International Journal* 17(2): 183–198.

Shiwaku, K., A. Sakurai, and R. Shaw. 2016. *Disaster resilience of education systems: Experiences from Japan*. Tokyo, Japan: Springer.

Slovic, P. 1987. The perception of risk. *Science* 236(4799): 280–285.

Tashiro, A., and R. Shaw. 2020. COVID-19 pandemic response in Japan: What is behind the initial flattening of the curve? *Sustainability* 12(13): Article 5250.

Thi, M.T.T., R. Shaw, and Y. Takeuchi. 2012. Climate disaster resilience of the education sector in Thua Thien Hue province. *Central Vietnam. Natural Hazards* 63(2): 685–709.

UN (United Nation). 2015. Transforming our world: The 2030 agenda for sustainable development, resolution adopted by the UN General Assembly on 25 September 2015. https://www.un.org/ga/search/view_doc.asp?symbol=A/RES/70/1&Lang=E. Accessed 17 Nov 2020.

UN (United Nation). 2020. *Policy brief: Education during COVID-19 and beyond*. New York: United Nations.

UNISDR (United Nations International Strategy for Disaster Reduction). 2015. Sendai framework for disaster risk reduction 2015–2030. Geneva: UNISDR. https://www.preventionweb.net/files/43291_sendaiframeworkfordrren.pdf. Accessed 20 Jun 2020.

UNISDR and Global Alliance for Disaster Risk Reduction and Resilience in the Education Sector. 2017. Comprehensive school safety. Geneva: UNISDR. https://www.preventionweb.net/files/51335_cssbooklet2017updated.pdf. Accessed 20 Jun 2020.

UNDRR (United Nations Office for Disaster Risk Reduction). 2017a. Open-ended intergovernmental expert working group on indicators and terminology relating to disaster risk reduction and UNGA endorsement. https://www.preventionweb.net/drr-framework/open-ended-working-group/. Accessed 20 Jun 2020.

UNDRR (United Nations Office for Disaster Risk Reduction). 2017b. Technical guidance for monitoring and reporting on progress in achieving the global targets of the Sendai framework. https://www.unisdr.org/files/54970_techguidancefdigitalhr.pdf. Accessed 20 Jun 2020.

UNESCO (United Nations Educational, Scientific and Cultural Organization). 2019. Education for sustainable development beyond 2019. UNESCO Executive Board Two hundred and sixth session, 20 February 2019. https://unesdoc.unesco.org/ark:/

48223/pf0000366797.locale=en?fbclid=IwAR2azPWljsBHoJq1cmIA16_kbpM8fDkN-P1_4YvEHoZ_wdXs3wYw0vzWdk8. Accessed 10 Oct 2020.

UNICEF (United Nations International Children's Emergency Fund). 2020. Technical note: Protecting the children during coronavirus pandemic. https://www.unicef.org/media/65991/file/Technical%20note:%20Protection%20of%20children%20during%20the%20coronavirus%20disease%202019%20(COVID-19)%20pandemic.pdf. Accessed 20 Jun 2020.

UNICEF and UNESCO (United Nations International Children's Emergency Fund and United Nations Educational, Scientific and Cultural Organization). 2009. Towards a learning culture of safety and resilience: Technical guidance for integrating disaster risk reduction in the school curriculum. https://unesdoc.unesco.org/ark:/48223/pf0000229336. Accessed 20 Jun 2020.

WHO (World Health Organization). 2014. An introduction to risk communication. http://www.who.int/riskcommunication/introduction-to-risk-communication.pdf?ua=1. Accessed 20 Jun 2020.

World Bank. 2020. The COVID-19 pandemic: Shocks to education and policy responses. https://openknowledge.worldbank.org/handle/10986/33696. Accessed 20 Jun 2020.

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Article

Digital Citizen Science for Responding to COVID-19 Crisis: Experiences from Iran

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Abstract: The Coronavirus Disease 2019 (COVID-19) pandemic has so far been the most severe global public health emergency in this century. Generally, citizen science can provide a complement to authoritative scientific practices for responding to this highly complex biological threat and its adverse consequences. Several citizen science projects have been designed and operationalized for responding to COVID-19 in Iran since the infection began. However, these projects have mostly been overlooked in the existing literature on citizen science. This research sheds light on the most significant online citizen science projects to respond to the COVID-19 crisis in Iran. Furthermore, it highlights some of the opportunities and challenges associated with the strengths and weaknesses of these projects. Moreover, this study captures and discusses some considerable insights and lessons learned from the failures and successes of these projects and provides solutions to overcome some recognized challenges and weaknesses of these projects. The outcomes of this synthesis provide potentially helpful directions for current and future citizen science projects—particularly those aiming to respond to biological disasters such as the COVID-19 pandemic.

Keywords: citizen science; crowdsourcing; coronavirus disease 2019 (COVID-19); user-generated content (UGC); volunteered geographic information (VGI); public health monitoring; public health promotion; emergency management; mobile health (mHealth); digital contact tracing

1. Introduction

Coronavirus Disease 2019 (COVID-19) has become undisputedly the most severe biological hazard that has been seen in the recent past. It is difficult to track the numbers, with more than 142 million people affected in 192 countries and territories as of mid-April 2021, resulting in more than 3 million deaths and numerous sufferings that have been impacting all parts of societies [1]. This is possibly the true representation of our globalized and inter-connected world, where risk is shared globally, yet disproportionately, depending on the country and community's vulnerability, exposures, capacities, governance mechanisms, technology advancement, innovation, and more importantly, citizen behavior. There is still a massive gap between our current state of knowledge and the knowledge we need as well as between the available resources and the resources we demand to effectively fight against COVID-19. COVID-19 is a novel type of biological hazard whose many aspects, such as biology, transmission mechanisms, spread and infection trajectory, and treatment, as well as short- and long-term physical, mental, social, and economic consequences, are often uncertain or not (fully) known. Hence, COVID-19 has raised many new questions and presented various challenges for scientists, practitioners, and policy-makers since the pandemic began. This pandemic has shown that professionals and governments are not always equipped or capable of responding to a biological disaster [2] alone, since real-time/near real-time geographically distributed data acquisition, data management, data processing and interpretation, data exchange, and information presentation are the core of its response strategy.

Citizen science is a scientific practice performed, in whole or in part, by volunteers from the general public [3]. The citizen science movement aims to connect people to science and bridge the gap between the public and scientists [4]. It empowers the general public to make a direct contribution to scientific research [5]. Public participation in scientific research often allows scientists to leverage the power of volunteers to accomplish tasks that would be too expensive or time-consuming to accomplish through other means [6]. Citizen science also offers other potential benefits to professionals and citizens. These include enabling the democratization of science, allowing the incorporation of local, traditional, or indigenous knowledge of citizens in scientific research, providing learning opportunities for citizens, raising awareness in citizens, increasing advocacy among citizens, promoting behavior change among citizens, and enhancing citizens' physical and mental health, personal enjoyment, social interaction, and satisfaction through contributing to scientific evidence [7–9]. The advent of information and communication technology (ICT) and the rise of Web 2.0 [10] over the past two decades have created a wide range of opportunities for citizen science. The online digital technologies can usually ease the establishment and management of citizen science projects for professionals, and can usually simplify the processing, dissemination, and presentation of the contents produced in citizen science projects for them [11]. These technologies can also facilitate the interactions and communications among professionals and people, allow geographically dispersed people to participate in citizen science projects, ease data gathering and content generation tasks for citizens, and help volunteers to enhance the quality of their contributions [11–14].

Recently, the field of citizen science has aroused increasing interest in various areas of health and biomedical sciences such as epidemiological monitoring, health behavior surveillance, environmental health study, molecular biology, and genomics (for more information, see [15–21]). However, to date, relatively less contribution has been made to this area compared to well-established areas of citizen science such as ecology, conservation, earth sciences, and astronomy [22]. The application of citizen science in the different phases of disaster management has also gradually been growing over the past few years. Citizen science has been deployed for addressing various types of disasters, such as earthquakes, floods, hurricanes, biological disasters, and nuclear disasters in previous projects [23] (for more information, see [24–28]). The experiences gained from using citizen science in past disasters such as the 2010 Haiti earthquake [29], West African Ebola virus epidemic [30,31], and Fukushima Daiichi nuclear disaster [32,33] have shown that generally, citizen science can provide great opportunities for enhancing disaster management capabilities and for reinforcing disaster resilience [34].

Given the various benefits, citizen science can generally provide a complement to authoritative scientific practices for responding to the COVID-19 pandemic and its detrimental consequences. Since the COVID-19 outbreak began, the use of online citizen science [35] for coping with COVID-19 and its adverse effects has been adopted for a range of purposes. For instance, online citizen science has been used for identification and mapping of suspected COVID-19 cases [36], tracing close contact with positive cases of COVID-19 [37], collecting respiratory sounds to aid diagnosis of COVID-19 [38], and studying risk factors for COVID-19 infection in a large, geographically heterogeneous cohort [39]. Furthermore, it has also been deployed in other COVID-19-related areas, such as designing proteins that can be able to bind to and neutralize COVID-19 [40], analyzing the existing medicines and anti-viral food molecules to identify previously unknown COVID-19 anti-viral properties [41], monitoring emotional responses to the COVID-19 pandemic

[42], and studying the long-term physical, mental, and socioeconomic impacts of the COVID-19 pandemic [43].

It is said [44] that ten years of innovation have been done within a year of the pandemic across the globe, and the same is true for Iran. While COVID-19 has brought significant pressure to the whole society, various social and technological innovations have emerged in Iran. For example, several citizen science projects have been designed and operationalized for responding to COVID-19 in Iran immediately after the infection hit the country—something that was not experienced before in the ecosystem of Iranian citizen science projects. Since Iran was one of the first countries affected by the pandemic, most of the Iranian COVID-19-related citizen science projects are among the first examples of their kind in the world. However, they have not been (well-)documented in the related literature so far, similar to the former Iranian citizen science projects. Differences in culture, language, educational system, political system, deployed instruments, adopted protocols and procedures, funding structures, etc., across the world might influence how citizen science is understood, valued, implemented, and grown [45]. Therefore, every single citizen science project usually has its own characteristics which make it unique. In this sense, the documentation of citizen science projects across the globe is imperative to understand different attitudes towards citizen science, to reflect barriers to implementation and development of projects, to capture different adopted solutions and to record experiences, knowledge, insights, and understanding to be used in future contributions. Detailed capturing and investigation of the cumulated experiences and lessons learned from failures and successes of the performed citizen science projects are essential to improve future stages of current citizen science projects and successful implementation and improvement of future citizen science projects.

The main goals of this research are (1) to highlight the most significant online citizen science projects that were carried out for responding to the COVID-19 crisis in Iran, (2) to highlight some of the opportunities and challenges associated with the strengths and weaknesses of these projects, (3) to provide solutions to overcome these weaknesses, (4) to provide lessons learned and insights from Iranian COVID-19-related projects for deploying in the current and future related citizen science projects and directing future researches in this area. This research makes interdisciplinary connections between citizen science and other domains such as emergency management, public health, GIScience, informatics, and information technology (IT) to achieve the aforementioned goals. The remainder of this paper is organized as follows: Section 2 provides a brief overview of some of the main characteristics and typologies of citizen science projects. Section 3 aims to shed light on the state of citizen science in Iran that has been overlooked in the related literature and provides a brief overview of the situation of the Iranian citizen science ecosystem where COVID-19-related citizen science projects have been grown. Section 4 presents a brief overview of the timeline and condition of COVID-19 in Iran. Section 5 reviews the state of volunteering for coping with the COVID-19 crisis in Iran. Section 6 introduces five significant COVID-19-related online citizen science projects launched by 31 December 2020 in Iran in detail. Based on these backgrounds, Section 7 presents some causes of success and failure of COVID-19-related online citizen science projects, discusses some salient insights obtained from these projects, and offers some directions for improving current and future citizen science projects—particularly those for coping with COVID-19 or tackling future pandemics. Finally, the last section is reserved for the conclusion and some recommendations for future work.

2. Characteristics and Typologies of Citizen Science Projects

Citizen science projects can be classified in many ways considering their various characteristics. For example, they can be categorized into two major classes based on their main outcomes: a scientific/research outcome or a science-informed management/policy/response outcome [46,47]. Citizen science projects can also be categorized based on their leadership approach. A citizen science project can have top-down or bottom-up leadership. The citizen science projects that are majorly led by scientists/researchers working in an academic or a research institution (i.e., scientist-/researcher-led citizen science project), managers/practitioners of the public sector (hereinafter referred to as public sector-led citizen science project), and staff at a civil-society organization (i.e., civil-society-led citizen science project) use a top-down leadership approach. Citizen science projects that are led by an individual (i.e., individual-led citizen science project) or a community (i.e., community-led citizen science project) use bottom-up leadership [46,47]. Categorization of citizen science activities based on the expected engagement length for the fulfillment of the task(s) in citizen science projects is also feasible. Depending on the nature of the tasks, some tasks in some citizen science projects can be fulfilled by the one-time contributions of citizens. However, to fulfill some other types of citizen science tasks, citizens are expected to engage more than once in the project. For these types of tasks, the expected engagement length can range from a short-term engagement (a few days or weeks) to long-term engagement (every day and/or over a long period of time) [46,48,49]. The stage(s) of volunteers' involvement can also be used as a means of classification for citizen science activities. Volunteers can be involved in a single stage (including problem definition, study design, research tools/methods design, data gathering and basic processing/interpretation, data analysis and interpretation, or presentation and dissemination of results) or multiple stages of a scientific practice [46,48]. Shirk, et al. [50] divided citizen science projects depending on the degree of participation. In Shirk et al.'s developed typology [50] (hereinafter referred to as Shirk et al. typology), the citizen science projects were classified into five main categories: (1) "contractual" projects, where communities request professional researchers to perform a specific scientific investigation and report on the results; (2) "contributory" projects, which are generally designed by professionals (e.g., scientists and researchers) and for which citizens primarily contribute data; (3) "collaborative" projects, which are generally designed by professionals and for which citizens contribute data but also help to refine project design, analyze data, and/or disseminate findings; (4) "co-created" projects, which are designed by professionals and citizens working together and for which at least some of the public participants are actively engaged in most or all aspects of the research process; and (5) "collegial" contributions, where non-credentialed individuals perform research independently with varying degrees of expected recognition by professionals. Haklay [51] proposed a typology (hereinafter referred to as Haklay typology) for the classification of the levels of participation in citizen science projects. In this typology, four levels of participation in citizen science were identified: (1) "crowdsourcing", where the citizen acts as a sensor or participates in volunteered computing, (2) "distributed intelligence", where the citizen performs as a basic interpreter, (3) "participatory science", where the citizen contributes to problem definition and data collection, and (4) "extreme citizen science", which includes collaboration between the citizen and scientists in problem definition, data collection, and data analysis.

3. Citizen Science in Iran

The state of citizen science in Iran has not been investigated to date. In Iran, similar to many other countries [52,53], citizen science in its modern form has grown in the last decade but it is still a relatively novel and unknown concept. So far, the "Academy of Persian Language and Literature", the official regulatory body of the Persian language in Iran, has not introduced a Persian equivalent for the term "citizen science". However, there are several unofficial parallel translations of the term "citizen science" in Persian. Among these translations, two Persian terms of "Elm Shahrvandi" and "Daneshvari Shahrvandi" are used more frequently than others. The term "Elm Shahrvandi" literally means "the science of citizen" but may also mean "the science of citizenship" in Persian. This depends on the context in which it occurs (thus, this could sometimes be misleading if one has no background in this subject). The other more popular proposed translation, "Daneshvari Shahrvandi" literally implies "conducting the scientific action by citizen".

Overall, the term of citizen science (i.e., the different proposed translations for citizen science in Persian) is not a familiar and widely-used term in laity and academia in Iran. Moreover, currently, no organization exists in Iran to serve as a central reference point for various stakeholders of citizen science, nor to bring various stakeholders of citizen science together and create a network, to coordinate and support the citizen science landscape, and to encourage and accelerate the growth of the citizen science movement in the country. Furthermore, it is noteworthy that citizen science is not currently consolidated in national research programs in Iran.

Almost all of the relatively few existing active or completed Iranian citizen science projects have been introduced with explicitly related terminologies to citizen science (such as crowdsourcing project, participatory monitoring project, community-based monitoring project, community-based conservation project, amateur observation project, and self-reporting project) or even without referring to an explicitly related term rather than a citizen science project. Consequently, many of the participants who are involved in the Iranian citizen science projects may not even be aware that they are participating in citizen science projects. Furthermore, while the characteristics of a citizen science activity [8,47,54] can be recognized in all of these projects, the lack of a common understanding about the notion of citizen science (and its various levels and types) among the professionals has led to the underestimation and neglect of some existing Iranian citizen science projects when it comes to listing them in Iran. To the best of our knowledge, most Iranian citizen science projects were founded (or co-founded) by non-governmental organizations (NGOs) and grassroots groups, mainly unknown among the general public and their potential stakeholder groups at large. As a result, these projects have substantially remained unnoticed and undocumented in the existing literature on citizen science.

Some of the existing Iranian citizen science projects (active or completed) focus on biodiversity mapping, monitoring, and conservation (e.g., see "Iran Bird Watching" (http://www.iranbirdwatching.ir (accessed on 31 August 2021)), "IRAN-VultureConservation" (https://www.vultures.ir (accessed on 31 August 2021)), "TehranBirds" (http://tehranbirds.com (accessed on 31 August 2021)), "PersianLeopard" (http://persianleopard.com (accessed on 31 August 2021)), "PLAN4theLAND's Project on Monitoring of Breeding Birds in Hara Protected Area" [55], "Qeshm Island's Community-based Hawksbill Turtle Conservation Project" [56], and "Common Swift Voluntary Conservation Project" (http://www.iranianbirdingclub.com (accessed on 31 August 2021))). Astronomy is a branch of science that has a high potential for attracting the contributions of volunteers in scientific research in Iran as over 10,000 active amateur astronomers (at different skill levels) and a higher number of astronomy and space enthusiasts live in Iran [57,58]. There are a few good examples of professional-amateur (pro-am) [59] shoulder-to-shoulder collaborations in the country, where teams of skilled amateur astronomers tightly work together with professional astronomers for conducting formal scientific activities and research (e.g., the monthly sighting of the lunar crescent and conducting of the related research for Hijri calendar purposes that has been organized by "Estehlal Headquarters" in Iran over the past three decades [60,61]). Moreover, there have been some opportunities for Iranian amateurs and enthusiasts to voluntarily contribute to the astronomy- and space-themed domestic citizen science projects based upon their level of expertise (e.g., see "Search for Impact Craters in Iran" [62], "Meteorite Hunting Project in Lut Desert of Iran"[63], "Dark Sky Map of Iran" (http://www.astromap.ir (accessed on 31 August 2021)), "Observation and Recording of Perseids Meteor Shower Project" (http://ramm.ir (accessed on 31 August 2021)), "Transit of Mercury Data Collection Project"[64], and "Crater Timings During Lunar Eclipse Project" [65]). While the aforementioned scientific domains are the focus of most of the existing Iranian citizen science projects, some examples of domestic citizen science projects can be distinguished in other disciplines, including ecosystem monitoring ("Participatory Project for Monitoring of Nowrozlo Wetland Ecosystem" [66]), crowdmapping (e.g., "Mashhad Mobile Map" (https://map.mashhad.ir) (accessed on 31 August 2021), "RAYA" (https://map.tehran.ir (accessed on 31 August

2021)), and "ZARBIN Tree Mapping Project" [67]) and public health monitoring and promotion ("Blood Pressure Self-reporting Program" [68] of "Iran National Mobilization for Controlling of Hypertension"—see the Section 6 for the COVID-19-related instances of this category of domestic citizen science projects). It is noteworthy that before the COVID-19 outbreak in Iran, with the exception of an Iranian government-run crowdsourcing project of "Blood Pressure Self-reporting Program" (2019) that attracted approx. 500,000 volunteer citizens [69,70], all the searchable Iranian citizen science projects were small-sized projects (from several to less than 1000 members).

In addition to the domestic citizen science projects, Iranian citizen scientists are also contributing to global citizen science projects such as "OpenStreetMap (OSM)", "eBird", "iNaturalist", "Galaxy Zoo", and "International Astronomical Search Collaboration" (e.g., "All Iran Asteroid Search Campaign", which has been organized in collaboration with Iran's "Nojum Magazine" [71]), and contributing to the projects and campaigns of international organizations such as "International Meteor Organization". It should be noted that the OSM community in Iran (https://osmiran.ir (accessed on 31 August 2021)) is very active and dynamic, and to the best of our knowledge, the OSM is the most popular long-running citizen science project among Iranian citizen scientists according to the number of daily active contributors. There are also a relatively large number of studies related to the OSM project (mostly in the domain of GIScience) from the perspective of volunteered geographic information (VGI) [72] that were conducted by Iranian universities and research institutes. These studies are very significant among other Iranian research works related to citizen science according to the volume of contribution.

4. COVID-19 Pandemic in Iran

The first human cases of COVID-19 were reported in Wuhan, China in December 2019 [73]. The World Health Organization (WHO) declared the COVID-19 outbreak as a Public Health Emergency of International Concern (PHEIC) on 30 January 2020 following the spread of the infection beyond the borders of China [74]. In late January 2020, Iran adopted its first specific precautionary measures against the spread of the COVID-19. These measures included checking the body temperature of passengers arriving from China at the airports [75,76] among others.

On 19 February 2020, the first cases of COVID-19 infection were confirmed and officially announced in Iran [76,77]. On the following day, the Iranian government established the National Task Force for Fighting Coronavirus—a high-level task force with the full authority to lead and coordinate the response to COVID-19 in the country [78,79]. By the end of February 2020, the COVID-19 virus spread was reported in over 60 countries and territories around the world [80]. On 1 March 2020, the total number of confirmed COVID-19 cases in Iran reached 978 (including 385 new daily confirmed cases) [81]. On the same day, following the spike in the number of positive COVID-19 cases in the Republic of Korea, Italy, Iran, and Japan, the WHO highlighted the epidemics in these countries as its greatest concern [82]. The WHO declared the COVID-19 outbreak as a pandemic on 11 March 2020 due to the rapid spread of the infection across the globe and the substantial number of cases reported worldwide [74]. Since then, the virus has continued to spread across the globe, including Iran. By 31 December 2020, a total of 1,225,143 COVID-19 cases have been confirmed, 55,223 people have died, and 988,838 people have recovered from the COVID-19 disease in Iran [83].

5. Civic Participation through Volunteering for Coping with COVID-19 Crisis in Iran

Civic participation [84,85] is a key principle for promoting emergency and crisis management and enhancing resilience [86–88]. Volunteering [86,89] as one of the pillars of civic participation can significantly contribute to the spectrum of emergency and crisis management phases, from mitigation/prevention and preparedness to response and recovery [90–92]. In the ongoing COVID-19 crisis, volunteers around the world have played influential roles in responding to the pandemic and mitigating its health, social and economic impacts on citizens and communities, and they have provided invaluable assistance for the formal organizations and governments [93–95].

The role of voluntary and charitable activities in responding to natural disasters and crises is significant and remarkable in Iran [96]. This is also the case in the current unprecedented state of public health emergency in Iran. Since the beginning of the COVID-19 outbreak, hundreds of thousands of volunteers across the country have stepped up and played a role in supporting their communities, the healthcare system, and other related public sectors. In many cases, the reasons behind volunteering in Iran (such as the participation of volunteers in different phases of emergency and crisis management) are linked to the moral, ethical, and religious values, beliefs, and motives of altruism, benevolence, compassion, humanitarianism, collectivism, cooperation, and attaining the pleasure of God (that have been widely instructed, strongly emphasized, and greatly praised in the rich Iranian-Islamic culture of the country) [96–99]. In this context, the faithful and devoted contributions of the unaffiliated (spontaneous) [86,100] and affiliated volunteers [86,101] to the health and welfare of the nation (along with the invaluable selfless, tireless, and diligent services of the Iranian healthcare professionals and practitioners from other sectors) have assisted the government in strengthening the battle against COVID-19 at a time when the country's combat against COVID-19 has been impeded due to tremendous adverse effects of the tough sanctions against Iran [75,102–104]. Moreover, these dedicated voluntary efforts together with invaluable and sympathetic services of the public and private sectors have considerably helped citizens to overcome post-traumatic stresses [105] of COVID-19. They have also raised hope and promoted solidarity in society. Volunteers have been involved in various activities such as the production of protective equipment (e.g., mask, gown, and coverall); disinfection of public surfaces; providing assistive/professional services at medical centers; providing social work, chaplaincy, and spiritual care services; meal preparation and distribution; hygiene kits and items distribution; shopping; running other errands and driving for elderly and vulnerable people; serving at checkpoints; performing burial rituals; creating cultural products and artworks, donations of blood (and plasma), money, goods, and facilities; and waiving rental fees. Science, technology, and education are other areas where Iranian volunteers have made contributions since the beginning of the outbreak in the country (e.g., answering online surveys related to COVID-19 designed by researchers, participating in Iranian COVID-19 vaccines and drug clinical trials, designing open-source ventilators, disinfection devices, and low-cost mask- and glove-making machines, and educating the community on how to prevent COVID-19). In the following sections, some of the significant examples of online citizen science activities in Iran in response to COVID-19 as a form of volunteering in science will be introduced and discussed in detail.

6. Iranian Online Citizen Science Projects for Responding to COVID-19

Since the beginning of the COVID-19 outbreak, Iranians have contributed to various COVID-19-related domestic and global citizen science projects. By 31 December 2020, five significant domestic online projects with citizen science characteristics [8,47,54], including the "Ministry of Health and Medical Education" (MOHME) of Iran's project for COVID-19 self-assessment and self-reporting (hereinafter referred to as CSASR project), AC19 project, Mask project, Gharbalgar COVID-19 project, and the project of "China-Iran Co-operation Group against COVID-19 Disease" (hereinafter referred to as CHIACD project) can be identified. The main thematic areas of these projects can be listed as (1) self-assessment and self-reporting of COVID-19 related symptoms (CSASR and AC19 projects), (2) digital contact tracing (Mask project), (3) COVID-19 cough audio sample collection (Gharbalgar COVID-19 project), and (4) translation of COVID-19 educational, scientific, and technical materials for responding to COVID-19 (CHIACD project). Three of these identified projects (CSASR, AC19, Gharbalgar COVID-19) can be categorized as contributory (crowdsourcing) citizen science projects, and the rest (Mask and CHIACD) are collegial (extreme) citizen science projects (for more information, see Sections 6.1–6.4). As these five Iranian COVID-19-related online citizen science projects have remained unnoticed and undocumented in the existing literature in this area, their specifications and characteristics will be presented, classified, and discussed in Sections 6.1–6.4.

6.1. COVID-19 Self-Assessment and Self-Reporting System and Application (App)

The CSASR project—an online project for COVID-19 self-assessment and self-reporting—was launched by MOHME of Iran [106] (https://self.salamat.gov.ir) on 4 March 2020 under the schemes of the "Iran National Mobilization Against COVID-19" program [107]. Iranian citizens can participate in this nationwide surveillance project on a voluntary basis. To use this online web tool that is linked to the electronic health records (EHRs) of Iranians, a volunteer participant is required to provide his/her national identity number, date of birth (for validation of the identity), place of residence (province and county), and mobile phone number. By answering a few questions about the symptoms and risk factors, this tool helps the participant to voluntarily assess and report his/her symptoms. This tool, then, determines whether the participant should visit a healthcare center for further assessment and testing. The identified suspected cases of COVID-19 through this web tool are provided with advice about personal and familial protection and referred to the nearest selected health center. The participants are enabled to update and re-submit their health condition and symptom information anytime in this system. The identified suspected cases of COVID-19 through this system are contacted by healthcare workers so that further investigations can be conducted, and contact tracing can be undertaken [106] under the "Iran National Mobilization Against COVID-19" program [107]. The crowdsourced data through this symptom tracking [106] system provided the public health officials with a clearer picture of the spatio-temporal spread of COVID-19 across the country and allowed them to implement a data-driven response in the early stages of the outbreak. This participatory system enables authorities to perform early screening of citizens and triage suspected cases. Moreover, by reducing unnecessary visits to medical centers, this web tool has decreased the risk of citizens' exposure to the disease, prevented more spread of infection, and reduced the burden on the healthcare system. Based on the latest publicly available information, by 3 April 2020, over 12 million people self-reported their symptoms and health condition via this system [108]. The number of participants in CSASR project is the highest number ever reported (by 31 December 2020) in an Iranian citizen science project (for more information, see Section 3 and Table 1). The general specifications of the CSASR project (including the project's scientific area, the number of contributors, the least expected engagement length needed for the fulfillment of the project's task, the adopted technology for data collection, and the launch date) were summarized and presented in Table 1.

Table 1. The general specifications of five identified Iranian COVID-19-related online citizen science projects.

Project Name	Scientific Area	Number of Contributors/Registered Users	Least Expected Engagement Length for Task(s) Fulfillment	Technology for Data Collection/Data Exchange	Launch Date
CSASR	Epidemiological Monitoring	>12 million (by 3 April 2020)	One-time (if there is no change in the contributor's health condition after the first contribution)	Dedicated Web App	4 March 2020
AC19	Epidemiological Monitoring	≈4 million (by 15 March 2020)	One-time (if there is no change in the contributor's health condition after the first contribution)	Dedicated Web App/Dedicated Mobile App	3 March 2020

Mask	Epidemiological Monitoring	>1 million (by 21 April 2020)	Long-term	Dedicated Web App/Dedicated Mobile App	2 March 2020
Gharbalgar COVID-19	Artificial Intelligence	≈500 (by 28 April 2020)	One-time	Dedicated Web App/Dedicated Mobile App	10 April 2020
CHIACD	Community Health	≈300 (in early May 2020)	One-time/Short-term (depending on the type of the task)	Social Media	24 February 2020

Some of the main characteristics of the CSASR project (including the outcome of the project, the project's leadership approach, the stage of volunteers' involvement in the project, the type of project based on Shirk et al. typology, and the type of project based on Haklay typology) were categorized based on the presented typologies in Section 2 and were presented in Table 2.

Table 2. Some of the main characteristics of five identified Iranian COVID-19-related online citizen science projects.

Project Name	Outcome of Citizen Science Project	Leadership Approach	Stage(s) of Volunteers' Involvement	Type of Project (Shirk et al. Typology)	Type of Project (Haklay Typology)
CSASR	Science-informed management/policy/response	Top-down: public sector-led	Single-stage: data gathering and basic processing/interpretation	Contributory	Crowdsourcing
AC19	Science-informed management/policy/response	Top-down: public sector-led	Single-stage: data gathering and basic processing/interpretation	Contributory	Crowdsourcing
Mask	Science-informed management/policy/response	Bottom-up: community-led	Multiple stages: problem definition, study design, research tools/methods design, data gathering and basic processing/interpretation, data analysis, and interpretation	Collegial	Extreme
Gharbalgar COVID-19	Scientific/research	Top-down: scientist-/researcher-led	Single-stage: data gathering and basic processing/interpretation	Contributory	Crowdsourcing
CHIACD	Science-informed management/policy/response	Bottom-up: community-led	Multiple stages: problem definition, study design, data gathering and basic processing/interpretation, presentation, and dissemination of results	Collegial	Extreme

In addition to the aforementioned main official system designed for self-assessment, self-reporting, and monitoring of COVID-19 in Iran, the "COVID-19 Disease Operation Management Headquarters in Tehran Metropolis" in collaboration with the "Ministry of Information and Communications Technology (MICT) of Iran" set up another government-led mobile (for Android platforms) and web app named "AC19" (https://ac19.ir) on 3 March 2020 for COVID-19 self-assessment. To register in this app, the volunteers need a mobile phone number. The app asks users for their personal and biometric information (name/username, city of residence, gender, age, weight, and height). Next, users answer a series of questions about their symptoms, past medical history and underlying disease, and exposure history to evaluate whether they should visit a healthcare provider or physician for further COVID-19 related assessment. The app also gives some recommendations on what to do next. The users can repeat this online self-assessment test anytime and update their information in this app. The app also offers other services for users, such as providing the latest COVID-19 news, updates and advice from reliable sources, governmental agencies, and medical centers' information. Contrary to the current version of the app that only records the user's city of residence, the app had collected the precise location of the user via GPS in addition to the information about the user's city of residence (that was directly provided by the user) in the early releases of this app—the functionality that had enabled the initiative to obtain VGI about the distribution of suspected COVID-19 cases at a fine spatial scale beside the coarse spatial scale. Iran's minister of MICT revealed a fine-scale COVID-19 aggregate risk map for the Greater Tehran area [109] and a coarse-scale COVID-19 aggregate risk map for Iran [110] to the public using the crowdsourced information through the AC19 app on 9 March 2020 and 11 March 2020, respectively. The acquired crowdsourced information from this app was used by the officials, majorly in the first stages of the pandemic in Iran. In this term, the gathered information by this app served as a complementary data source for conducting a rough estimate of COVID-19 distribution and size of the outbreak in Tehran and across the country. It also helped raise the awareness of the public about the spread of the infection, which convinced citizens to stay at home. According to the latest publicly available information, by 15 March 2020, approx. 4 million volunteers contributed to this system [111]. The general specifications of the AC19 project (including the project's scientific area, the number of contributors, the least expected engagement length needed for the fulfillment of the project's task, the adopted technology for data collection, and the launch date) were summarized and presented in Table 1. Moreover, some of the main characteristics of the AC19 project (including the outcome of the project, the project's leadership approach, the stage of volunteers' involvement in the project, the type of project based on Shirk et al. typology, and the type of project based on Haklay typology) were categorized based on the presented typologies in Section 2 and were presented in Table 2.

6.2. COVID-19 Digital Contact Tracing App

The "Mask" app (https://mask.ir (accessed on 31 August 2021)) was initially designed for digital contact tracing (also known as proximity tracing or app-based contact tracing) [106,112] based on a centralized architecture [113]. This app was voluntarily developed by a group of professors, students, and graduates in the fields of Computer Engineering and Mathematical Sciences from Iranian universities (including "Sharif University of Technology", "Shahid Beheshti University", and "Amirkabir University of Technology") in collaboration with a group of medical specialists in response to the outbreak of COVID-19 in their country. This non-profit project was launched on 2 March 2020 and was later endorsed and supported by MOHME of Iran [114]. Citizens' participation in this contact tracing project was on a voluntary basis through the released mobile (for Android platforms) or web versions of the app. Once the app was downloaded or delivered over the internet through a browser interface, the users were required to register in the system using an Iranian mobile phone number and provide some information on their health condition to benefit from all the functionalities of the app. The project could log memory of all close proximity contacts of the app users using Bluetooth, GPS, manual pinning of the contact location, or scanning of barcode and QR code. The users could also record the close physical contact information of their family members using this app. The app allowed users to be informed if in the past 14 days they were closely exposed to any other app users who had been definitely diagnosed with COVID-19 by MOHME's medical centers without revealing the identity of the infected person. Furthermore, a COVID-19 symptom checker tool for self-reporting of the daily health condition of the app users was integrated in the app. This self-evaluation function told the app users what to do next and if they needed to get medical care by asking a few questions on their health condition and symptoms and by deploying the records of the users. Besides the aforementioned major services of this app that were only available for the registered users, the app provided an interactive grid heat map of the confirmed and suspicious COVID-19 cases across Iran (produced based on the obtained data from Iran's MOHME) and daily statistics, news, and educational and awareness materials about the COVID-19 disease that were open to the public [115–117]. Based on the latest publicly available information, on 21 April 2020, the total number of active installed instances of this contact tracing app (downloaded from different Android marketplaces or the project's website) exceeded 1 million installations (for more information, see Section 7.3.1.1) [118]. Due to the relatively low uptake of this app (which has also has been a challenging issue for many similar projects worldwide—for more information, see Section 7.3.1), the Mask project stopped its digital contact tracing service in early November 2020. The general specifications of the Mask project (including the project's scientific area, the number of registered users, the least expected engagement length needed for the fulfillment of the project's task, the adopted technology for data collection, and the launch date) were summarized and presented in Table 1. Furthermore, some of the main characteristics of the Mask project (including the outcome of the project, the project's leadership approach, the stages of volunteers' involvement in the project, the type of project based on Shirk et al. typology, and the type of project based on Haklay typology) were categorized based on the presented typologies in Section 2 and were presented in Table 2.

6.3. COVID-19 Cough Audio Sample Collection

The "Machine Intelligence and Robotics Department, University of Tehran", Iran launched a crowdsourcing program named "Gharbalgar COVID-19" [119] on 10 April 2020 for collecting cough sounds as well as the basic demographics and medical history of the participants. The crowdsourced data through this app is used by the researchers of this department for the training of machine learning-based predictive models that are developed for the early screening and diagnosis of suspicious and positive COVID-19 cases. Both healthy and unhealthy participants were welcomed in this project. To collect the data from the volunteers in this program, a mobile app was released for Android devices (available in Persian and Arabic languages) and a web app was developed (available in the Persian language) for the devices using other operating systems. The data was gathered from app users by utilizing a basic questionnaire and recording a few seconds of coughing through the microphone of the device [119,120]. By 28 April 2020, almost 500 volunteers contributed to the Gharbalgar COVID-19 project. The general specifications of the Gharbalgar COVID-19 project (including the project's scientific area, the number of contributors, the least expected engagement length needed for the fulfillment of the project's task, the adopted technology for data collection, and the launch date) were summarized and presented in Table 1. Moreover, some of the main characteristics of the Gharbalgar COVID-19 project (including the outcome of the project, the project's leadership approach, the stage of volunteers' involvement in the project, the type of project based on Shirk et al. typology, and the type of project based on Haklay typology) were categorized based on the presented typologies in Section 2 and were presented in Table 2.

6.4. Translation of COVID-19 Educational, Scientific, and Technical Materials

Initiated by a Chinese language instructor, the CHIACD project [121] was established on 24 February 2020. The project was established at the early stages of the pandemic when the appropriate and reliable resources about prevention and protection methods against COVID-19 in languages other than Chinese were limited. Thus, this project aims to raise awareness and educate the Iranians about the COVID-19 disease by voluntary gathering, synthesizing, and translating the Chinese educational and scientific materials about COVID-19, presenting the produced outputs in appropriate formats, and disseminating them in society. Moreover, it aims to transfer China's experiences in fighting COVID-19 to the Iranian health workers through voluntary translation and dissemination of the Chinese educational, scientific, and technical materials about COVID-19 [122]. The first core members of this voluntary group were the Chinese and Persian language students and scholars from Iran and China. Later, new volunteers with different backgrounds (e.g., medical sciences and engineering), nationalities (Afghan volunteers), and Chinese and Persian language familiarity levels have joined this team over time. To put various capabilities and the expertise of the volunteers to better use, and to facilitate the collaboration and drive the group's objectives, the volunteers' activities have been structured under the following working groups: (1) information collection, (2) general translation, (3) medical translation, (4) external relations with the health workers and centers, (5) graphic design, (6) video production, (7) proofreading and quality assurance, and (8) digital products dissemination. The group mainly uses WeChat, a messaging and social media app to organize the group's activities, hold meetings, facilitate the communication between members and working groups, assign tasks, and exchange raw and produced digital materials. The group is obtaining COVID-19 related information only from authoritative and reliable Chinese sources. Public translation services that can be performed by a translator's general knowledge are mostly conducted by volunteer translators from fields other than medical sciences in this project. To enhance the quality of the medical specialized translation tasks, these translations are only performed by or under the direct supervision of the volunteer translators with a medical science background. Furthermore, before the dissemination of the group's translated products to the audience of the project, all the products are reviewed carefully by a team volunteers to ensure the appropriate quality of the final products. The generated contents of the group are shared on official pages and groups of the project on social media and messaging platforms (Instagram, Aparat, Telegram, and Twitter) for the general public audience of the group. In addition to the group's commitment to raising the awareness of the citizens about the COVID-19 disease, the group has been able to play a role in creating a direct bridge between Iranian and Chinese health workers and medical centers for exchanging their latest scientific information and experiences alongside the existing formal intergovernmental collaborations. In this term, the group is voluntarily collaborating with an Iranian social network for medical science professionals named "TritApp" (https://tritapp.net (accessed on 31 August 2021)) for establishing the communications and translation of the exchanged Persian and Chinese questions and answers between Iranian and Chinese health workers and medical centers in the two countries [123]. In early May 2020, the total number of volunteer members in the CHIACD project was around 300. The general specifications of the CHIACD project (including the project's scientific area, the number of contributors, the least expected engagement length needed for the fulfillment of the project's tasks, the adopted technology for data collection/data exchange, and the launch date) were summarized and presented in Table 1. Furthermore, some of the main characteristics of the CHIACD project (including the outcome of the project, the project's leadership approach, the stages of volunteers' involvement in the project, the type of project based on Shirk et al. typology, and the type of project based on Haklay typology) were categorized based on the presented typologies in Section 2 and were presented in Table 2.

7. Insights from the Past for the Current and Future COVID-19-Related Citizen Science Projects

In the following sections, some insights from five selected Iranian COVID-19-related citizen science projects as well as other related studies in this area will be presented and discussed to be used in citizen science projects in the future, particularly those in the domain of biological disasters such as COVID-19.

7.1. Initial Steps Needed for Capacity Building for Citizen Science in Public Sector and Academic and Research Institutions of Iran

To build the capacity for citizen science projects, five critical steps can be recognized: (1) identifying and engaging all actors in the citizen science projects, and enhancing the visibility of citizen science activities, (2) assessing the capabilities and needs of stakeholders, (3) developing citizen science projects' visions, missions, and action framework, (4) developing resources (e.g., developing technical infrastructure, guidelines, and educational material and provision of financial and human resources), and (5) evaluating the implementation to foster further development [124]. Citizen science capacity building is an iterative and adaptive mechanism that requires the active engagement of all stakeholders from society, science, and policy [124].

In Iran, the government has a significant influence on social, economic, and technological changes. As discussed earlier, citizen science is a relatively new concept in Iran. Currently, citizen science is not integrated into the organizational culture of governmental organizations in Iran. Thus, most of the influential people in governmental organizations who can benefit from citizen science might be unfamiliar and lack the necessary knowledge regarding how this approach can be leveraged to address various challenges encountered by their organization. Furthermore, similar to many other countries, there is still considerable skepticism among the Iranian policy-makers, decision-makers, and practitioners on the quality and trustworthiness [125] of the user-generated content (UGC) [126] produced in the citizen science projects; consequently, even many of those who are familiar with the concept usually have hesitations using such data in formal applications. Raising the profile of citizen science within an organization usually rests on the leadership of senior staff. Hence, before citizens are expected to embrace the citizen science projects, one of the vital tasks for building the capacity for government-driven citizen science projects in Iran is to raise the knowledge and come to a common understanding among the key personnel in the governmental organizations (particularly those whose involvement in and support from the ecosystem of citizen science projects is essential) about this concept, its pros and cons, and its potential applications for attaining the missions of their organizations and distributed problem-solving. Furthermore, it is necessary to change the conventional mindset of the official stakeholders of citizen science about the quality of citizen scientists' generated content—an attitude that always underestimates the citizen science data quality. The previous studies showed that the quality of generated data in citizen science projects can approach and even may exceed that of authoritative sources [127,128]. Therefore, to deal with the existing concerns among officials, it is crucial to highlight some successful examples of citizen science projects across the globe whose outputs have been employed for solving real-world problems, and it is necessary to raise their knowledge about the existing adopted approaches for assuring and enhancing the quality of the contributions in citizen science programs. As it was mentioned before, there is currently no governmental or non-governmental organization in charge of supporting, developing, and coordinating citizen science activities in Iran. As one of the first steps, it is therefore crucial to establish a governmental entity for promoting and coordinating the utilization of citizen science across the Iranian government and society. This entity has to train human resources, provide consultation services, finance citizen science activities, provide technical and legal support, regulate and standardize citizen science activities, connect various stakeholders, and develop best practices for designing, implementing, and assessing citizen science programs in order to surmount the existing obstacles, limitations, and delays and to build the capacity for citizen science.

Citizen science can permit academic and research institutions to access to previously inaccessible areas by enriching and enlarging their research scope, can consolidate the position and recognition of academic and research institutions in society, can provide new resources and opportunities to them, and can enhance public trust in them [129]. Academic and research institutions can contribute to citizen science by providing their professional infrastructure and facilities, educational and research capabilities, ethical and legal background, and funding [129]. While in many countries, citizen science was established and mainly has been developed by academic and research bodies [130], the role of Iranian academic and research institutions in running citizen science projects has not been prominent yet. To the best of our knowledge, the most notable Iranian citizen science projects were initiated from outside of academia and research bodies. The main outcomes of notable Iranian citizen science projects (for more information, see Section 3) are mostly science-informed management, policy, or response. Citizen science projects with scientific/research outcomes in the list of notable Iranian citizen science projects are in the minority. The concept of citizen science is less well-known in most Iranian academic and research institutions. Furthermore, citizen science has not been included in the academic and research culture of Iranian academic and research institutions yet. Currently, there is no institutional structure or venue dedicated to leading, coordinating, promoting, supporting, and funding citizen science (or Open Science [131] as a related concept) within the "Ministry of Science Research and Technology" (MSRT) of Iran, MOHME of Iran, or Iranian academic and research institutions. Nowadays, many scientists and researchers across the world have been approached to design more inclusive citizen science practices to involve diverse groups of citizens in various aspects of the scientific and research process. However, in the landscape of Iranian scientist-/researcher-led citizen science projects, to date, the designed participation level for the involvement of citizens in the implemented citizen science projects has not gone beyond the crowdsourcing level, mostly due to a lack of knowledge and understanding about the concept and various aspects of citizen science. These are also the case in the context of Iranian COVID-19-related citizen science projects. Among the five identified Iranian COVID-19-related online citizen science projects, only one project (Gharbalgar COVID-19) was initiated by scientists/researchers. Similar to other Iranian scientist-/researcher-led citizen science projects, the level of citizens' participation in this project was limited to the crowdsourcing level (Table 2).

The aforementioned recommendations for building the capacity for citizen science within the Iranian government are also generally valid for citizen science capacity building in Iranian academic and research institutions. Establishment of the institutional structures and entities in charge of leading, developing strategies and operating framework, coordinating, promoting, providing technical and legal supports, and funding citizen science within Iran's academic and research system at different levels should be considered as a high priority task. Organizing scientific training programs and events for raising awareness, reaching a common understanding, and fostering knowledge and skills of Iranian scientists and researchers about various theoretical and practical aspects of citizen science is pivotal in shaping the citizen science movement in academic and research institutions. Consequently, it should also be given higher priority. Furthermore, as another initial step for building the capacity for citizen science and accelerating citizen science movement within Iranian academic and research institutions, it is crucial to develop free customizable platforms by (for) Iranian academic and research bodies. This will ease conducting a variety of citizen science projects by scientists and researchers.

7.2. Enhancing the Effectiveness of Citizen Science Projects for Emergency Response through Early Preparedness and Coordination

Contrary to many other thematic categories of citizen science, citizen science projects relevant to emergency response must become operational in a short time since deferring the issue can cause loss of life and other costs to societies and nations. Hence, to foster the effectiveness of citizen science projects for emergency response, it is crucial to build the capacity for these projects, mainly during the disaster preparedness phase. Although, in general, citizen science-based solutions have still not been embedded in the normal working routines of Iranian organizations (including the MOHME of Iran) and the organizations do not have clear and long-term visions and comprehensive plans and strategies in this area, the MOHME of Iran unveiled its COVID-19 self-assessment and self-reporting system and integrated it into its official screening and follow-up system and EHR database within a relatively short time after confirming the first cases of COVID-19 in the country. This unprecedented rapid digital response was mainly powered by the accumulated data, knowledge, and skills, and created an organizational structure and established IT infrastructure in MOHME of Iran during its prior crowdsourcing project, the Blood Pressure Self-reporting Program in 2019, which was Iran's first large-scale experience in employing citizen science in healthcare. The previous studies [106,132,133] also showed that the pre-established organizational structures, organizational memory, pre-defined objectives, protocols, procedures and strategies, and pre-existing generic and scalable citizen science infrastructures can significantly reduce the time and cost of implementation and can enhance the organizational adaptability and applicability of citizen science programs for responding to disasters and emergencies.

The COVID-19 pandemic is the first biological disaster experience at this scale in Iran. Therefore, similar to many other countries, many loopholes and shortcomings (e.g., see [134]) emerged in the activities of the public health emergency response system in the initial phase of the epidemic in the country. In the early days of the COVID-19 outbreak in Iran, there have been simultaneous efforts (the public sector-led projects of CSASR and AC19 and the community-led project of Mask) for crowdsourcing various health information for means of epidemiological monitoring (Tables 1 and 2). There is considerable overlap between the goals and missions of two government-led projects (CSASR and AC19)—therefore, the contents of the gathered data in these two projects were almost the same. Furthermore, there are some areas that both Mask project and the two aforementioned government-led projects are commonly collecting data about (for more information, see Sections 6.1 and 6.2). While each of these three citizen science projects may perform well within its own functional areas, the overlaps or some similarities among the goals and missions of these projects have at best caused the fragmentation of crowdsourced health information and have at worst also caused the occurrence of duplications or redundancies in the gathered information, which is a waste of time, energy, and resources for the stakeholders and the volunteers. To reduce/eliminate the redundant data production efforts in the government-led citizen science programs, governments have to define/revise their data gathering policies, strategies, and procedures, as well as their collaboration plans in such a way to clarify and assign the roles and responsibilities of each stakeholder of citizen science projects for responding to the public health crisis in advance. Moreover, to reduce/eliminate the duplication and fragmentation of the multi-sector health information (including crowdsourced and authoritative health information) generated in the different phases of the public health crisis and to share the generated contents between the authorized stakeholders, it is necessary to aggregate and exchange the sparse datasets in compliance with the data privacy laws, protection standards, and protocols [18,135,136] in a real-time (or near real-time) manner through an integrated information system [137], data clearinghouse [138], or geoportal [139]. In this context, adopting the pre-approved protocols and standards [140] provides an effective solution for data interoperability [141] and facilitates the seamless integration of the generated crowdsourced datasets. It is noteworthy that the provision of these arrangements (which facilitates multi-sector citizen science data exchanging and data integration) may also increase the role of accredited non-government-led citizen science projects (i.e., the projects led by private research bodies and private academic institutions, civil societies, and communities) in gathering data (such as public health- and emergency-related data), which have been mostly crowdsourced so far by the governments. The inclusion of accredited non-governmental citizen science initiatives in the focused domain may trigger more social and technological innovations in data crowdsourcing that lead to providing more diversified options for the citizens (to opt into the project that best fits their requirements and preferences). Furthermore, this inclusion may facilitate the connection with people and communities and may foster the sense of trust among citizens as data contributors (by involving the non-governmental bodies in the administrative process of data gathering). Consequently, these may increase the number of data contributors in the focused domain.

7.3. Organizational Measures for Enhancing the Recruitment and Retention of Volunteers

Volunteers are one of the main pillars in all citizen science projects. In this sense, generally, recruiting and retaining a higher numbers of volunteer participants can accelerate the achievements of most citizen science projects and is integral to the success of many of them [142]. The recruitment and retention of citizen scientists in citizen science projects needs some organizational structures and measures. However, in Iran, which has less history in the modern form of citizen science, most citizen science project organizers generally have not had any prior training and experience in setting up and managing these projects. Moreover, as mentioned earlier, there are no scientific or professional institutions for guiding and training Iranian citizen science project organizers and transferring good practices to them. Therefore, even many of conventional organizational measures that have been widely practiced in modern citizen science projects for improving the initial participation and long-term engagement of citizen scientists have not been (fully-) implemented in most Iranian citizen projects.

The figures on the number of contributors/registered users in the identified Iranian COVID-19-related citizen science projects (Table 1) indicate that the three identified projects in the area of epidemiological monitoring (CSASR, AC19, and Mask) could attract vast populations of people to themselves. This level of public attention (in terms of the number of contributors/registered users) to Iranian citizen science projects was not experienced before in the ecosystem of Iranian citizen science projects. Engagement in CSASR and AC19 projects have a mostly one-time nature. However, for the proper fulfillment of the contact tracing task in the Mask project, a long-term engagement of the participants is necessary (Table 2). Compared with many other citizen science projects, the issues of recruitment and retaining of volunteers play a more critical and decisive role in the degree of failure and success of the digital contact tracing projects (for more information, see Section 7.3.1). This feature makes contact tracing projects good choices for studying the impact of various influencing factors on the initial participation and sustained participation of the people in the citizen science projects and creates a common ground for discussing and synthesizing the insights that can be obtained from previous related researches and practical experiences inside and outside the field of citizen science.

In this sense, in the following sections, some lessons learned from the Iranian contact tracing project about recruitment as well as some generic directions obtained from other related citizen science projects will be presented and discussed. These highlighted issues and directions might be deployed in the future not only for enhancing the recruitment and retention of volunteers in the citizen science projects for tracing infectious diseases such as COVID-19 but also in other categories of citizen science projects.

7.3.1. Volunteer Recruitment and Retention in Contact Tracing Projects

Previous studies showed that voluntary digital contact tracing could reduce the spread of the COVID-19 epidemic [143,144]. However, a digital contact tracing project can be a game-changer only if it can attract and sustain the citizens' mass engagement [143,145,146]. A study [147] in the UK estimated that the COVID-19 epidemic could be completely suppressed if at least 80% of all smartphone users (56% of the total population) adopt the digital contact tracing app. Hence, while there were early hopes that the digital contact tracing projects could play a key role in controlling COVID-19 infection in the affected countries, due to the unfulfillment of the required mass public engagement in these projects, there is no single country to date that can claim that its digital contact tracing project has significantly contributed to the reduction of COVID-19 transmission [148]. For instance, a report [149] from Iceland, a country that has had the largest uptake of a digital contact tracing app in the world (38% of the country's population as of May 2020), indicates that the impact of digital contact tracing on reducing COVID-19 spread has not been significant yet. Another example is France's digital contact tracing app that was initially downloaded by about 1.9 million people (approx. 2.8% of the country's total population) as of June 2020; however, shortly after, around 0.5 million of those 1.9 million people uninstalled or deactivated the app. Until late June 2020, only 68 users of this app reported that they had been diagnosed with COVID-19; these reports resulted in notifications for only 14 other app users who had contacted these people [150]. The situation in Iran is also more or less the same. Iran was one of the pioneers in the launching of the digital contact tracing app (Mask app). The country has a young population—out of the approx. 83 million people living in Iran in 2019, 24.6% of the country's population was under the age of 15, 22% of the population was 15–29 years old, and only 6.4% of Iran's population was 64 years old and above [151]. Furthermore, according to a conservative estimate [152] in 2019, Iran had a considerable smartphone penetration rate of approx. 55% (for other estimates, see [153,154]). Moreover, the internet penetration rate in Iran stood at 70% by the end of 2018 [155]. However, according to available statistics, as of early June 2020 (more than 3 months after the start of the Mask project), the app had only about 1 million users (≈approx. 1.2 % of the country's population) in Iran [156]. Even if it is ideally assumed that all the people who activated the Mask app on their smartphones actively used the main functionality of the app—contact tracing (which is a very unrealistic assumption), similar to most other existing COVID-19 contact tracing apps, the uptake rate of this app was well below the estimated threshold needed for a digital contact tracing app to be significantly effective.

Prior to the onset of the pandemic, various studies had been conducted to identify the antecedent factors for uptake and engagement with apps such as participatory mobile health (mHealth) apps (for more details, see [157–159]). Within the growing field of citizen science, some studies also have been conducted to determine what factors influence people's participation in citizen science projects and why volunteers continue their participation in these projects. These studies intended to shed light on the various dimensions such as social, behavioral, cognitive, motivational, legal, managerial, technical, and technological dimensions affecting the participation and engagement of people in citizen science projects. The various influencing factors on the initial participation and sustained participation of people in the citizen science projects generally can be categorized into two broad categories of dispositional factors (i.e., attributes of individuals) and organizational factors (i.e., attributes of the project and its organizers) [142,160,161].

Most of the recent studies that have raised the problem of COVID-19 contact tracing apps' low adoption from the organizational perspective have placed great emphasis on studying the impact of various technical factors and technology-related legal and ethical factors such as users' privacy, data protection, transparency, service quality, instrument and interface design on the participation and long-term engagement of people in contact tracing projects. Generally, the successful addressing of technical issues and technology-related legal and ethical issues that were extensively studied and discussed in these studies (which were mostly conducted in western societies and have backgrounds other than citizen science) may lead to an increase in the adoption and user retention in the COVID-19 contact tracing apps. However, there are also some other less-discussed organizational factors beyond these factors that significantly impact the uptake and long-term deployment of contact tracing apps. To this end, in the following sections, the role of promotion, advertising, and marketing, as well as recognition, communication, and feedback on the recruitment and retention of volunteers in the contact tracing project will be discussed in more detail through forging interdisciplinary connections among citizen science, psychology, sociology, emergency management, and public health.

7.3.1.1. Promotion, Advertising, and Marketing

Despite their considerable benefits, contact tracing apps are characterized by various technical shortcomings and inconveniences as well as legal and ethical concerns. Thus, if one became aware of the existence of a contact tracing project, he/she would usually estimate the perceived costs (including the various shortcomings, inconveniences, and concerns) and benefits (including personal and public benefits) of deploying a contact tracing app to decide whether to install (or continue to deploy) a contact tracing app. If the benefits of the decision outweigh its costs, the person adopts the app (or maintains its use) [162–164]. To ensure mass adoption and continued use of a contact tracing app, in addition to the necessity for minimizing the costs of participation in a contact tracing project (through addressing the existing shortcomings, inconveniences, and concerns) and the need for informing people about the launch of the contact tracing program, citizens must be made aware of the various benefits of attending a digital contact tracing project [163,165,166], the contents of the tasks and the updates from the project. It was argued that the lack of awareness of an existing citizen science project (i.e., volunteering opportunity) and lack of information and understanding of volunteering task(s), volunteering responsibilities, participation requirements, and personal and public benefits of the project are key barriers to recruiting people with diverse backgrounds in a citizen science project [142,167]. This implies that the promotion, advertising, and marketing for citizen science projects are effective ways for recruiting volunteers in citizen science projects and stimulating the uptake of citizen science project apps by informing people and raising public awareness and understanding [142,168]. The insufficient promotion and advertising or use of inefficient marketing strategies are among the most significant reasons for the failure of many Iranian citizen science projects in attracting citizens, and the Mask project is not an exception to this.

Contrary to most of the existing COVID-19 contact tracing apps in the world that were implemented or funded by governments, the well-developed Mask app was produced on a non-governmental, non-profit, and voluntary basis by a group of computer science and engineering scholars and experts. Consequently, the project organizers had intrinsically limited resources and authority for mounting mass nationwide advertising campaigns compared with many other similar projects around the world. The project was initially introduced by the advertisement contents (e.g., text, image, and video advertisements) shared through the project's website, official channels on social media and messaging platforms (Telegram Messenger, Instagram, Twitter, Soroush Messenger, and Bale Messenger), and an online video-sharing platform (Aparat), that in total, these channels have been able to attract approx. 25,000 members and followers so far. The project also used celebrity and elite endorsement on social media in the early weeks of its launch. Furthermore, the project has received media coverage by various online Iranian news agencies as well as online and print newspapers since its appearance. Following the scientific and ethical approval of the project by MOHME, the MOHME and several high-ranking state officials have also formally recommended installing the Mask app or have talked about it. Moreover, the Islamic Republic of Iran Broadcasting (IRIB)—Iran's state-owned media corporation (which owns over 70 television channels and 80 radio stations)—has covered and introduced the Mask project in several television programs.

The list of television programs related to the Mask project that were broadcasted by IRIB, as well as the formal endorsement, recommendation, and promotion of the Mask project by the MOHME and several high-ranking Iranian state officials from 2 March to 30 June 2020, were extracted from the accessible online sources. It should be noted that this list may miss a few other incidents (e.g., the Mask project's few broadcasted short video advertisements on the IRIB television service) whose details (i.e., the incident or the occurrence date of it) could not be retrieved from available online sources. A total of 13 different incidents were identified on 9 different days in the abovementioned period, the details of which are demonstrated in Table 3.

Table 3. The list of identified television programs broadcasted by IRIB related to the Mask project and the endorsement, recommendation, or promotion of the Mask project by the government from 2 March to 30 June 2020.

Event Day No.	Date	Details
1	21 March 2020	Content: news report on Mask project [169] Host program (IRIB TV channel): a news program (IRIB TV1) Duration: 3:00 min Viewership level of host program: high
2	5 April 2020	Content: the minister of MOHME of Iran sent an official letter to the director-general of IRIB to introduce the Mask project and request for the showing of the animated advertisement videos of the project and the coverage of it in the IRIB's programs [170] Content: news report on Mask project [171] Host program (IRIB TV channel): a news program (IRIB TV1) Duration: 2:16 min Viewership level of host program: low Content: news report on Mask project [171] Host program (IRIB TV channel): a news program (IRINN) Duration: 2:16 min Viewership level of host program: low
3	17 April 2020	Content: mass SMS message of MOHME of Iran to all cell phones nationwide with recommendation to install Mask app [172]
4	19 April 2020	Content: the president of Iran introduced the Mask app and its applications in monitoring and tracking the disease [173] Venue: in the briefing of National Task Force for Combating Coronavirus Disease weekly meeting (live broadcasted by IRINN) Content: news report on Mask project [174] Host program (IRIB TV channel): a news program (IRIB TV1) Duration: 2:54 min Viewership level of host program: high Content: talk show on Mask project [175] Host program (IRIB TV channel): an entrepreneurship and business program (IRIB TV1) Duration: 23:15 min Viewership level of host program: low Content: in-studio interview on Mask project [176] Host program (IRIB TV channel): a news program (IRIB TV1) Duration: 6:25 min Viewership level of host program: high
5	20 April 2020	Content: the spokesperson of the government of Iran announced the government's (and the MOHME of Iran's) support of the Mask app and recommended Iranians to use it [177] Venue: in the weekly press conference of the spokesperson of the government of Iran (live broadcasted by IRINN)
6	28 April 2020	Content: the spokesperson of MOHME of Iran announced that the Mask app is the only approved app by MOHME [178] Venue: in MOHME press conference
7	9 May 2020	Content: the deputy minister of MOHME of Iran recommended Iranians to install the Mask app [179] Venue: in MOHME press conference (live broadcasted by IRINN)
8	29 May 2020	Content: COVID-19 daily status report by the spokesperson of MOHME of Iran (including the recommendation to Iranians to use Mask app) [180]

		Host program (IRIB TV channel): a news program (IRINN) Duration: 00:36 min Viewership level of host program: low
9	17 June 2020	Content: news report on Mask project [181] Host program (IRIB TV channel): a news program (IRIB TV1) Duration: 3:17 min Viewership level of host program: high

The Android version of Mask app (that is the most popular version of the app) can be downloaded either from Iranian Android marketplaces (Cafe Bazaar, Myket, Charkhoneh) or from the project's website. Among these, Cafe Bazaar is by far the most popular platform for downloading this app. Figure 1 shows the "total number of active installed instances of the Mask app (downloaded from Cafe Bazaar Android marketplace)" (TNAIIMA) per day from 2 March to 30 June 2020. The TNAIIMA ranged from 0 (on 2 March 2020) to 1,037,129 (on 12 May 2020) and reached 851,602 on 30 June 2020.

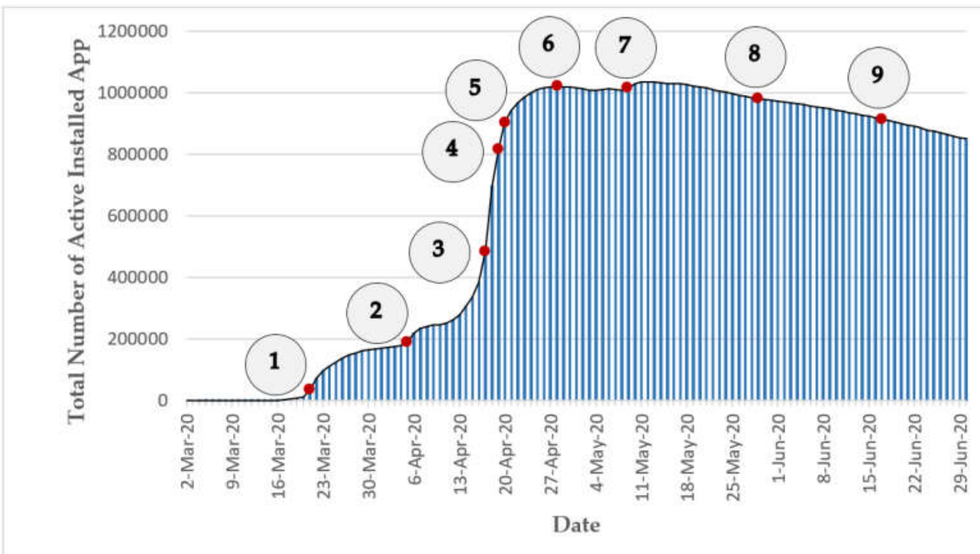

Figure 1. (1) Total number of active installed Mask apps per day (raw data courtesy of Mask project); (2) timeline of the identified television programs broadcasted by IRIB related to the Mask project and the endorsement, recommendation, or promotion of the Mask project by the government (from 2 March to 30 June 2020). Notes: the figures for the total number of active installed Mask apps per day are limited to the installed instances of the Mask app downloaded from Cafe Bazaar Android marketplace; the numbering of the events is the same as that in Table 3.

Furthermore, the amount of change in the TNAIIMA (compared to the previous day) per day (i.e., the total number of new installations of the app on each day minus the total number of new uninstallations of the app on each day) was computed and illustrated in Figure 2. The amounts of change in the TNAIIMA in the study period ranged from −5755 (i.e., at least 5755 new uninstallations of the app compared to the previous day) on 24 June 2020 to +209,478 (i.e., at least 209,478 new installations of the app compared to the previous day) on 18 April 2020. The timeline of the identified events (see Table 3) was also depicted in Figures 1 and 2.

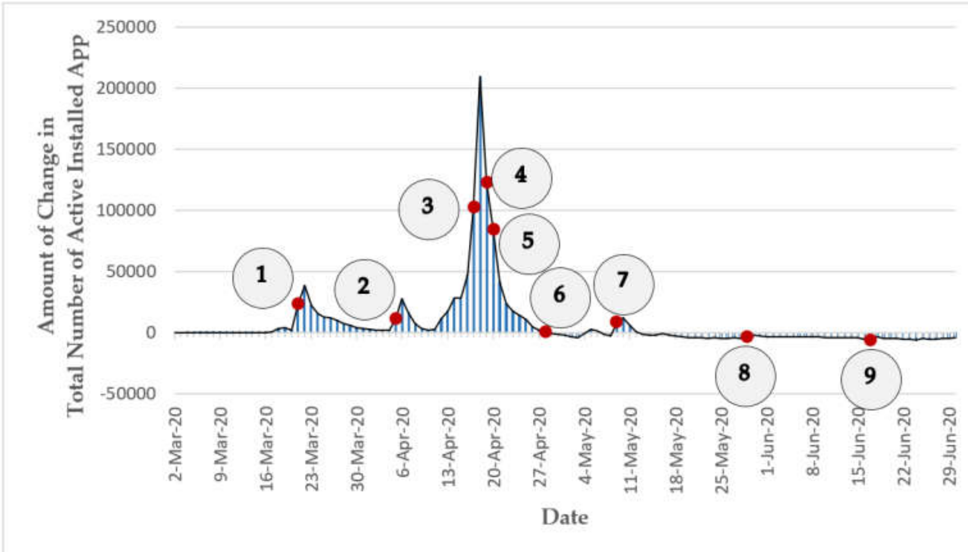

Figure 2. (1) Amount of change in the total number of active installed Mask apps (compared with the previous day) per day; (2) timeline of the identified television programs broadcasted by IRIB related to the Mask project and the endorsement, recommendation, or promotion of Mask project by the government (from 2 March to 30 June 2020). Notes: the figures for the amount of change in the total number of active installed Mask apps per day are limited to the installed instances of the Mask app downloaded from Cafe Bazaar Android marketplace; the numbering of the events is the same as that in Table 3.

Figure 2 shows that in most cases, a significant rise in the increment rate of TNAIIMA on the event day and its consecutive day (event day no. 1, 2, 3, 7 in Table 3) occurred after an event, or a significant drop in the reduction rate of TNAIIMA on the event day and/or its following day (event day no. 6, 8, 9 in Table 3) occurred compared to the previous day of the event. However, the magnitudes of these significant growths in increment rate or declines in the reduction rate of TNAIIMA are not the same. The significant escalation in the increment rate or the significant drop in the reduction rate of the TNAIIMA declines over the following few days of the event. Figure 2 also illustrates that the project experienced the sharpest rise in the increment rate of the TNAIIMA following event day no. 3 (sending the mass short message service (SMS) text messages by MOHME to all Iranian cell phones on 17 April 2020)—with at least 312,557 new installations on the event day and its consecutive day. Immediately after this intense wave of app installations, there were a series of television programs related to the Mask project and the endorsement and recommendation of the Mask project by the government on 19 and 20 April 2020 (event day no. 4 and 5). However, although there were considerable numbers of new installations of the app on and right after the days of event day no. 4 and 5 (at least 122,876, 84,615, and 41,088 new installations of the app on 19, 20, and 21 April 2020, respectively), they were less than the massive wave of new installations occurring after event day no. 3. It is expected that promotion, advertising, and marketing can potentially increase the total number of new installations and decrease the total of new uninstallations of the app each day. While more comprehensive research is still needed in this area, it seems that the cumulative effects of event day no. 3, 4, and 5 were (among) the main driving force(s) for the observed massive increase in the total number of new installations of the app between 17 and 21 April 2020 (at least 561,136 new installations during this period).

Some previous studies highlighted the positive impact of SMS text messaging on improving the uptake of public health interventions [182,183]. The SMS is also integral to emergency communications [184] for timely and fast dissemination of notifications for mitigating damage and reducing life loss. A previous study [185] showed that SMS, followed by television, have more comprehensive information dissemination capabilities than other information mediums, including microblogs and news portals in disaster pre-warning and recommendation. This study found that the SMS has a shorter delay time, higher coverage ratio, and speed of information dissemination among the other media mentioned above. A survey [186] in early April 2020 indicated that among the different organizations involved in COVID-19 crisis management in Iran, Iranians trust the healthcare system and MOHME of Iran the most, followed by the media (IRIB television service was identified as the most trusted and used media among the others in this study). The quantitative analysis is out of the scope of this study. While more data is required (that was not available for this research) and more comprehensive research is needed, it seems that these could (at least partially) explain the reason for attracting enormous numbers of people to the project in a short time after event day no. 3. According to another survey [187] in early April 2020 in Iran, 65.7% of survey participants identified the IRIB as their primary source of news about COVID-19, followed by other mediums including Telegram Messenger (8.3%), Instagram (7.2%), satellite television channels (6.3%), news websites (6.1%), friends and acquaintances (1.9%), and WhatsApp (1.4%). Moreover, 63.4% said they received their primary education about COVID-19 mainly from the IRIB. The equivalent figures for Telegram Messenger (7.2%), Instagram (7.2%), satellite television channels (3.9%), news websites (7.8%), friends and acquaintances (4.2%), and WhatsApp (2.8%) are significantly lower. These findings reveal the vast influence of the nation-wide media—IRIB (particularly the IRIB television service as the most popular service of IRIB)—in shaping public opinion about COVID-19-related issues and may explain the substantial impact of the television programs on attracting people to the project. Previous studies highlighted the importance of adequate and effective advertising and communication frequency in strengthening the previous information and reinforcing the audiences' impression [188]. Therefore, while in general, it seems that the identified nine events served as the main driving forces behind the significant rise in the app's uptake, it can be hypothesized that the app could achieve higher uptake levels if the frequency of the events (media coverages, endorsements, etc., by the government) in the aforementioned period was appropriately increased.

Overall, it can be stated that in Iran, the government's role in raising public awareness about the COVID-related citizen science projects (such as the digital contact tracing project) was essential and irreplaceable. Additionally, the government plays a crucial role in informing people about the functionalities and requirements of these projects and their benefits for personal and public health and in encouraging citizens to adopt them due to its extensive and influential media power (mainly through the television service) and social capital [189] emerging from the health system (derived from the public trust in it). Therefore, the government should strengthen and expand its support for these projects, particularly for a participation-dependent voluntary project such as digital contact tracing, whose effectiveness and success is highly dependent on the broad participation of people in the project. Moreover, it should be noted that, similar to many other Iranian projects with citizen science characteristics, most of the participants who are involved in the Iranian COVID-19-related citizen science projects are not aware that they are participating in citizen science projects. Hence, raising the knowledge and understanding of the projects' audience and participants about the concept of citizen science and its various benefits, alongside introducing these projects under the term of citizen science, may help to enhance the recruitment and retention of volunteers in these projects. Therefore, involving these considerations during the promotion, advertisement, and marketing for these projects is necessary. Furthermore, as mentioned earlier in Section 4, the previous studies revealed that moral, ethical, and religious values, beliefs, and motives are the main drivers of voluntary activities for emergency and crisis response in Iran. Traditionally, most of these activities have been carried out in the offline context. Consequently, the sphere of prosocial behavior in response to emergency and crisis circumstances has not been well expanded into cyberspace in public opinion, and the culture of online volunteering in this context has not been adequately formed in Iranian society. To this end, it is crucial to tightly connect the value and necessity of the contribution of citizens in online

COVID-19-related citizen science projects (such as contact tracing programs) into the aforementioned moral, ethical, and religious values, beliefs, and motives. Therefore, since the media has a vast potential for promoting prosocial behavior and its drivers [190,191], the power of media should be exploited for promoting and recognizing moral, ethical, and religious merits of participating in COVID-19-related citizen science projects (including the contact tracing projects) in Iran that leads to fostering participation and long-term engagement of people in these projects. It is noteworthy that while generally, some mediums are more influential than others, the previous studies recommend the employment of a combination of different mediums (e.g., SMS, television, social media, news websites, print newspapers) for conveying the message and advertising, as this enhances the efficiency of information dissemination and marketing among various groups of audiences [185,192]. Thus, to raise public awareness and understanding about participation-dependent citizen science projects, it is crucial to take the distinct advantages of different mediums by exploiting combinations of communication channels.

7.3.1.2. Recognition, Communication, and Feedback

Various intrinsic and extrinsic motives [193,194] could drive the engagement of people in citizen science projects [195,196]. Intrinsic motivation refers to engagement in an activity due to the achievement of internal rewards such as a sense of enjoyment, satisfaction, or pride. Extrinsic motivation refers to participation in an activity because of obtaining a separable outcome (i.e., attaining a specific external reward or avoiding a negative consequence) such as a score, money, or fame [193,194]. Since the creation of the mechanisms for fostering the intrinsic motivations of people for engagement in citizen science projects is difficult and not always possible, many project organizers prefer to rely on using extrinsic motives. In citizen science, people generously contribute their valuable time and effort for free; therefore, it is essential that all contributions of volunteers be recognized appropriately by the organizers of citizen science projects regardless of the level of their contributions [142,195]. The recognition of volunteers' efforts in a meaningful and credible manner can also positively influence the long-term engagement of volunteers by extrinsically motivating them to continue their involvement in the project [168,197,198]. The form and amount of recognition should be appropriate to the nature of the project and tasks and consistent with the characteristics of volunteers such as their values, norms, and culture. Furthermore, the extrinsic incentives should be designed in a way that is not perceived as controlling an individual's behavior and reducing their autonomy [199]. Otherwise, it may undermine the intrinsic motivation of participants, change how tasks are perceived by volunteers, reduce the self-image and social approval benefits, and tempt participants to play the system or cheat, resulting in drop-out and/or inaccurate outputs [200–205]. Recognition can happen in various ways in citizen science projects, such as writing a thank you message for all contributors, offering a certificate, promoting volunteers' roles, or giving a gift, voucher, and monetary reward for high achievers [142,206]. The Iranian contact tracing app did not implement a concrete recognition system to cope with the drop-out problem. However, it seems that using the proper recognition and rewarding strategies in contact tracing projects such as the Mask app (and other similar citizen science projects in other areas) could assist in stimulating the app users' motivations and overcome the problem of declining volunteer participation and retention over time. In this sense, different rewarding mechanisms (e.g., providing verbal appreciation, adding a badge to the volunteer's online profile, offering a bonus or discount card, giving hygiene kits, and granting priority in receiving some services) should be carefully investigated to find the best solutions for providing incentives for long-term engagement of citizens in contact tracing projects and to ensure the trustworthiness of the data. It is noteworthy that the incentives for the contact tracing app users should be chosen in a way that does not cause injustice and consequently digital divide in the society (e.g., if the free hygiene kit is used as an external motive, it is required that the kits be also provided for the lower-income citizens besides the citizens who use a contact tracing app).

Citizen science projects require long-term outreach strategies and constant communication with the audiences via appropriate channels (e.g., email, SMS, blogs, discussion forums, and social networks) to sustain project engagement [132,168]. To this end, it is crucial to establish personalized communication with non-active members of the project, alongside frequent communication with the entire community [207]. As the level of involvement increases in a citizen science project from crowdsourcing to extreme citizen science (for more details, see: [208]), it is desirable to move from simple one-way communication to two-way communication (and more advanced levels of dialogic communication) in the project [132]. Like many other contact tracing projects, the Mask project suffered from the lack of a concrete communication plan for the retention of its users. However, it seems that defining and implementing a set of effective communication tactics is necessary for contact tracing projects such as Mask to cope with declining volunteer retention and drop-out over time.

The participants in the voluntary projects need to feel that what they are doing is useful and being appropriately used [160,209]. In this sense, providing continuous feedback on how a volunteer's overall contribution or the entire outcome of a citizen science project helps citizen scientists understand how their contributions were used and how they impacted science, society, and the environment [132,210]. Prior experiments demonstrated that positive feedback could enhance the intrinsic motivation of participants compared to neutral or no feedback. [211]. Therefore, providing feedback plays a vital role in volunteer retention in citizen science projects [168]. No feedback was given to the Mask project participants. However, it is expected that giving feedback to participants of a contact tracing app about the number of traced infected and suspected cases of COVID-19 through the app could encourage them to continue their contribution to the project. The Mask project did not provide the general outcome of the project (e.g., the number of detected cases and true notifications) to the public. Nevertheless, it is believed that announcing the general outcome of a contact tracing project to the general public and reflecting the positive contribution of the project to the epidemiological investigation, epidemic control, and consequently the public health to the society accordingly may motivate more citizens to install and use the app.

7.4. Social Media as a Platform for Citizen Science Emergency Response Projects

The platform of an online citizen science project [212] may offer one or several services on the internet such as the gathering, processing, searching, discovery, and sharing of UGC, presenting UGC and other related data, describing tasks and guidelines, providing educational and technical materials and tools, making the potential target audiences aware of the volunteering opportunity in the project, registering the volunteers, and providing social networking, communication, and discussion features for the stakeholders of the project.

Social media is an integral part of daily life in many societies, with over 3.6 billion active users worldwide in 2020 [213]. Social media platforms provide an online interactive environment built on the foundation of the Web 2.0 paradigm through which individuals, communities, and organizations can connect and communicate together, can generate, share, present, and search content, can discuss their issues and opinions, and can learn about, explore, advertise, and promote things [214,215]. Designing and implementing a platform for a citizen science project from scratch enables the project's organizers to personalize every aspect of the platform and the services it provides; however, this could be difficult, expensive, and time-consuming and might limit its visibility and adaptability. If developing a new platform for a citizen science project is not a feasible or optimal solution, an alternative option might be to use the customizable commercial/free citizen science platforms or deploy the existing non-specialized platforms such as social media platforms.

Previous studies have showed that social media can play an influential role in facilitating and shaping civic participation [216]. Social media allows for immediate interaction and communication with a large, diverse, and geographically dispersed audience. Most social media platforms are free to use and easy to start using. Moreover, many people are familiar with their features and functionalities. These platforms are usually built on robust, modern, scalable, fast, secure, and reliable infrastructures. Social media platforms can often effectively improve the awareness about and visibility of the activities. Consequently, the various features and functionalities of social media platforms can create many potential opportunities for providing the different services needed in citizen science projects.

Social media platforms have been mostly used as an advertising and promotion medium to recruit and retain volunteers in citizen science projects [217–219]. These platforms have also been deployed to facilitate interactive and real-time communication and discussion between citizens and other stakeholders of the citizen science projects, to provide feedback to volunteers, to post announcements and updates, to instruct volunteers, and to disseminate the projects' results [219–221]. Relatively few citizen science programs have gone one step further and leveraged the capabilities of social media platforms for collecting the contributions of citizen scientists. For example, Soysal, et al. [222] used social media for crowdmapping of the urban red fox population. To this end, volunteers were asked to send sighting reports and/or photographs of the urban red foxes they observed with the observation location (either by sending a GPS coordinate or nearest cross streets) and time (as well as other optional information) to the organizers of this project via Facebook, Twitter, or Instagram. As another example, to record Italian dialects and document their linguistic variation, a citizen science project [223] developed a Telegram Bot (an automated software that runs inside the Telegram Messenger environment). This app, which runs inside Telegram Messenger, enables a volunteer to submit his/her voice recording and to enrich it with the associated location to his/her dialect (either by sending a GPS location or inputting the name of the place) into the project.

Both top-down citizen science projects (citizen science projects with top-down leadership) and bottom-up citizen science projects (citizen science projects with bottom-up leadership; i.e., collegial citizen science projects) can benefit from the various services that can be offered by social media platforms. Notably, the bottom-up citizen science projects with limited resources and budgets and the (top-down or bottom-up) citizen science projects that need to be launched urgently may take advantage of social media's existing infrastructure to connect with the large numbers of potential audience and provide their services (e.g., collecting data, displaying or playing obtained data, discussing, advertising, and promoting) immediately and for free or at low cost. Two of the Iranian citizen science projects that were launched during the pandemic also took advantage of social media platforms for offering their services. Mask and CHIACD citizen science projects were both developed through a bottom-up approach by a group of volunteer citizens (without a top-down design and management of health and medical science professionals) in response to a biological crisis that impacted their society. The Mask project developed and launched its own platform for contact tracing in a short time after conceptualizing the project, relying on the profound expertise of its founders and its volunteer technical team in IT. Nevertheless, the Mask project employed a mixture of different social media platforms (Telegram Messenger, Instagram, Twitter, Soroush Messenger, Bale Messenger, and Aparat) for advertising and promoting itself in public and posting related news. Compared to the Mask project, the CHIACD project used social media's capabilities more extensively—the strategy that allowed the organizers to eliminate additional workload or costs for developing the project's platform. To this end, the CHIACD project leveraged the capacity of a combination of social media platforms (consisting of WeChat, Instagram, Aparat, Telegram, Twitter, and TritApp) to provide its various essential services such as UGC collection and raw data exchange, providing two-way communication, discussion, feedback, and output dissemination and presentation services. It is noteworthy that each social media platform has its own strengths and weaknesses; therefore, choosing the right social media platform or combination of social media platforms to provide the required services and functionalities for citizen science projects is pivotal to success.

8. Conclusions and Recommendation

This research shed light on the most significant online citizen science projects carried out to respond to the COVID-19 crisis in Iran. Moreover, this study attained and discussed some considerable insights and lessons learned from the failures and successes of these projects, enriching them by incorporating knowledge gained from other citizen science projects over the past years. Findings from this synthesis offer potentially valuable directions for the current and future citizen science projects that aim to respond to biological hazards such as the COVID-19 pandemic. This study highlighted some initial steps that need to be taken for capacity building for citizen science in Iran's public sector and academic and research institutions. This research also argued that the provision of an effective response to an outbreak such as the COVID-19 crisis through citizen science requires building capacity and needs preparation for conducting citizen science projects in advance. Furthermore, this study discussed the influence of various organizational factors on the recruitment and retention of volunteers in COVID-19-related citizen science projects and mainly digital contact tracing programs. Remarkably, we highlighted the prominent role of project promotion, advertising, and marketing as well as recognition, communication, and feedback provision for the volunteers' contributions on the participation and long-term engagement of participants of these projects that have been less focused on in the previous studies. This article also called attention to the high capacity of social media for providing a wide range of services (e.g., data acquisition, data presentation, discussion, advertisement, and promotion) for citizen science projects with limited resources and budgets or those required to be launched urgently. Limited/lack of access to up-to-date information about citizen science projects in Iran—particularly COVID-19-related citizen science projects—were two of the obstacles to doing this research. Moreover, the dearth of previous research on the various dimensions of Iranian COVID-19-related citizen science projects was among the main barriers to this research. However, we hope that this research can pave the way for future research in this direction.

COVID-19 has caused mental health problems among people worldwide, including people in Iran. Furthermore, schools and universities have been closed in Iran, and instruction has been switched to online as a part of measures to reduce the spread of COVID-19 in the country since late February 2020. This long-term disruption of in-class education has resulted in an education crisis in Iran, similar to many other countries. Engagement in citizen science projects could potentially improve the mental health and well-being of volunteers, and citizen science can serve as a beneficial educational tool for citizen scientists. Therefore, utilizing the potential capacity of relevant existing active Iranian citizen science projects such as those in the field of biodiversity monitoring, astronomy, and geographical mapping (while practicing social distancing) is recommended to reduce the aforementioned adverse consequences of COVID-19 in the country.

Citizen science has a broader implication in emergency response, one beyond this global pandemic. While citizen science has been studied extensively and practiced widely in some fields, relatively less contribution has been carried out on citizen science for disaster management. Currently, more than 4.6 billion people around the world actively use the internet. Moreover, the number of smartphone users worldwide today surpasses 3.5 billion and is to rise rapidly in the next few years. With the current penetration of the internet and smartphones, it is becoming much easier to engage people and communities in the disaster management process through citizen science. Higher engagement in these projects offers a vast range of opportunities, particularly for developing countries, where obtaining accurate and updated data and plans are always a significant challenge. The insights from this study can be used to overcome some existing barriers to operationalizing citizen science projects for disaster management and can be deployed to enhance the performance of these projects, particularly in developing countries.

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References

1. World Health Organization. WHO Coronavirus (COVID-19) Dashboard. Available online: https://covid19.who.int/ (accessed on 19 April 2021).
2. Narayanan, N.; Lacy, C.R.; Cruz, J.E.; Nahass, M.; Karp, J.; Barone, J.A.; Hermes-DeSantis, E.R. Disaster preparedness: biological threats and treatment options. *Pharmacother. J. Hum. Pharmacol. Drug Ther.* **2018**, *38*, 217–234.
3. Raddick, M.J.; Bracey, G.; Gay, P.L.; Lintott, C.J.; Cardamone, C.; Murray, P.; Schawinski, K.; Szalay, A.S.; Vandenberg, J. Galaxy Zoo: Motivations of citizen scientists. *arXiv Prepr.* **2013**, arXiv:1303.6886 .
4. Urválková, E.S.; Janoušková, S. Citizen science–bridging the gap between scientists and amateurs. *Chem. Teach. Int.* **2019**, *1*, https://doi.org/10.1515/cti-2018-0032.
5. Yang, D.; Wan, H.Y.; Huang, T.-K.; Liu, J. The role of citizen science in conservation under the telecoupling framework. *Sustainability* **2019**, *11*, 1108.
6. Braschler, B. Successfully implementing a citizen-scientist approach to insect monitoring in a resource-poor country. *BioScience* **2009**, *59*, 103–104.
7. Walker, D.W.; Smigaj, M.; Tani, M. The benefits and negative impacts of citizen science applications to water as experienced by participants and communities. *Wiley Interdiscip. Rev. Water* **2021**, *8*, e1488.
8. Robinson, L.D.; Cawthray, J.; West, S.E.; Bonn, A.; Ansine, J. Ten principles of citizen science. In *Citizen Science: Innovation in Open Science, Society and Policy*; Hecker, S., Haklay, M., Bowser, A., Makuch, Z., Vogel, J., Bonn, A., Eds.; UCL Press: London, UK, 2018.
9. Katapally, T.R. A Global Digital Citizen Science Policy to Tackle Pandemics Like COVID-19. *J. Med. Internet Res.* **2020**, *22*, e19357.
10. Thackeray, R.; Neiger, B.L.; Hanson, C.L.; McKenzie, J.F. Enhancing promotional strategies within social marketing programs: use of Web 2.0 social media. *Health Promot. Pract.* **2008**, *9*, 338–343.
11. Mazumdar, S.; Ceccaroni, L.; Piera, J.; Hölker, F.; Berre, A.; Arlinghaus, R.; Bowser, A. *Citizen Science: Innovation in Open Science, Society and Policy*; Hecker, S., Haklay, M., Bowser, A., Makuch, Z., Vogel, J., Bonn, A., Eds.; UCL Press: London, UK, 2018.
12. Skarlatidou, A.; Ponti, M.; Sprinks, J.; Nold, C.; Haklay, M.; Kanjo, E. User experience of digital technologies in citizen science. *J. Sci. Commun.* **2019**, *18*, http://doi.org/10.22323/2.18010501.
13. Curtis, V. *Online Citizen Science Projects: An Exploration of Motivation, Contribution and Participation*; The Open University: London, UK, 2015.
14. Aristeidou, M.; Herodotou, C. Online citizen science: A systematic review of effects on learning and scientific literacy. *Citiz. Sci. : Theory Pract.* **2020**, *5*, 1–12.
15. Wiggins, A.; Wilbanks, J. The rise of citizen science in health and biomedical research. *Am. J. Bioeth.* **2019**, *19*, 3–14.
16. King, A.C.; Winter, S.J.; Chrisinger, B.W.; Hua, J.; Banchoff, A.W. Maximizing the promise of citizen science to advance health and prevent disease. *Prev. Med.* **2019**, *119*, 44–47, doi:10.1016/j.ypmed.2018.12.016.
17. Schmitz, H.; Howe, C.L.; Armstrong, D.G.; Subbian, V. Leveraging mobile health applications for biomedical research and citizen science: a scoping review. *J. Am. Med. Inform. Assoc.* **2018**, *25*, 1685–1695, doi:10.1093/jamia/ocy130.
18. Majumder, M.A.; McGuire, A.L. Data Sharing in the Context of Health-Related Citizen Science. *J. Law Med. Ethics* **2020**, *48*, 167–177.
19. Craig, A.T.; Kama, N.; Fafale, G.; Bugoro, H. Citizen science as a tool for arboviral vector surveillance in a resourced-constrained setting: results of a pilot study in Honiara, Solomon Islands, 2019. *BMC Public Health* **2021**, *21*, 1–8.
20. Chauhan, G.; McClure, J.; Hekman, J.; Marsh, P.W.; Bailey, J.A.; Daniels, R.F.; Genereux, D.P.; Karlsson, E.K. Combining Citizen Science and Genomics to Investigate Tick, Pathogen, and Commensal Microbiome at Single-Tick Resolution. *Front Genet* **2020**, *10*, 1322–1322, doi:10.3389/fgene.2019.01322.

21. Ceccaroni, L.; Woods, S.M.; Sprinks, J.; Wilson, S.; Faustman, E.M.; Bonn, A.; Greshake Tzovaras, B.; Subirats, L.; Kimura, A.H. Citizen Science, Health, and Environmental Justice. In *The Science of Citizen Science*; Vohland, K., Land-Zandstra, A., Ceccaroni, L., Lemmens, R., Perelló, J., Ponti, M., Samson, R., Wagenknecht, K., Eds. Springer International Publishing: Cham, Switzerland, 2021; pp. 219–239, doi:10.1007/978-3-030-58278-4_12.
22. Den Broeder, L.; Devilee, J.; Van Oers, H.; Schuit, A.J.; Wagemakers, A. Citizen Science for public health. *Health Promot. Int.* **2016**, *33*, 505–514, doi:10.1093/heapro/daw086.
23. Chari, R.; Sayers, E.L.P.; Amiri, S.; Leinhos, M.; Kotzias, V.; Madrigano, J.; Thomas, E.V.; Carbone, E.G.; Uscher-Pines, L. Enhancing community preparedness: an inventory and analysis of disaster citizen science activities. *BMC Public Health* **2019**, *19*, 1–15.
24. Hicks, A.; Barclay, J.; Chilvers, J.; Armijos, M.T.; Oven, K.; Simmons, P.; Haklay, M. Global Mapping of Citizen Science Projects for Disaster Risk Reduction. *Front. Earth Sci.* **2019**, *7*, 226, doi:10.3389/feart.2019.00226.
25. Calyx, C. Sustaining Citizen Science beyond an Emergency. *Sustainability* **2020**, *12*, 4522.
26. Kenens, J.; Van Oudheusden, M.; Yoshizawa, G.; Van Hoyweghen, I. Science by, with and for citizens: rethinking 'citizen science' after the 2011 Fukushima disaster. *Palgrave Commun.* **2020**, *6*, 58, doi:10.1057/s41599-020-0434-3.
27. Paul, J.D.; Hannah, D.M.; Liu, W. Editorial: Citizen Science: Reducing Risk and Building Resilience to Natural Hazards. *Front. Earth Sci.* **2019**, *7*, 320, doi:10.3389/feart.2019.00320.
28. Herfort, B.; Lautenbach, S.; de Albuquerque, J.P.; Anderson, J.; Zipf, A. The evolution of humanitarian mapping within the OpenStreetMap community. *Sci. Rep.* **2021**, *11*, 1–15.
29. Soden, R.; Palen, L. From crowdsourced mapping to community mapping: The post-earthquake work of OpenStreetMap Haiti. In Proceedings of COOP 2014-Proceedings of the 11th International Conference on the Design of Cooperative Systems, Nice, France, 27–30 May 2014; pp. 311–326.
30. Singh, A.; Ahsan, F.; Blanchette, M.; Waldispühl, J. Lessons from an online massive genomics computer game. In Proceedings of Proceedings of the AAAI Conference on Human Computation and Crowdsourcing, Québec City, QC, Canada, 23–26 October 2017.
31. Smith, C. A case study of crowdsourcing imagery coding in natural disasters. In *Data Analytics in Digital Humanities*; Springer: Berlin/Heidelberg, Germany, 2017; pp. 217–230.
32. Brown, A.; Franken, P.; Bonner, S.; Dolezal, N.; Moross, J. Safecast: successful citizen-science for radiation measurement and communication after Fukushima. *J. Radiol. Prot.* **2016**, *36*, S82.
33. Reiher, C. Lay people and experts in citizen science: Monitoring radioactively contaminated food in post-Fukushima Japan. *Asien* **2016**, *140*, 56–73.
34. Kocaman, S.; Anbaroglu, B.; Gokceoglu, C.; Altan, O. A review on citizen science (CitSci) applications for disaster management. *Int. Arch. Photogramm. Remote Sens. Spat. Inf. Sci.* **2018**, *XLII-3/W4*, https://doi.org/10.5194/isprs-archives-XLII-3-W4-301-2018.
35. Doyle, C.; Li, Y.; Luczak-Roesch, M.; Anderson, D.; Glasson, B.; Boucher, M.; Brieseman, C.; Christenson, D.; Coton, M. What is online citizen science anyway? An educational perspective. *arXiv Prepr.* **2018**, arXiv:1805.00441 .
36. Antoniou, V.; Vassilakis, E.; Hatzaki, M. Is Crowdsourcing a Reliable Method for Mass Data Acquisition? The Case of COVID-19 Spread in Greece During Spring 2020. *ISPRS Int. J. Geo-Inf.* **2020**, *9*, 605.
37. Trivedi, A.; Vasisht, D. Digital contact tracing: technologies, shortcomings, and the path forward. *ACM SIGCOMM Comput. Commun. Rev.* **2020**, *50*, 75–81.
38. Brown, C.; Chauhan, J.; Grammenos, A.; Han, J.; Hasthanasombat, A.; Spathis, D.; Xia, T.; Cicuta, P.; Mascolo, C. Exploring automatic diagnosis of covid-19 from crowdsourced respiratory sound data. In Proceedings of Proceedings of the 26th ACM SIGKDD International Conference on Knowledge Discovery & Data Mining, San Diego, CA, USA, 6–10 July 2020; pp. 3474–3484.
39. Aung, S.; Vittinghoff, E.; Nah, G.; Peyser, N.D.; Pletcher, M.J.; Olgin, J.E.; Marcus, G.M. Characteristics and Behaviors Associated with Prevalent SARS-CoV-2 Infection. *Int. J. Gen. Med.* **2021**, *14*, 1063.
40. Yasinski, E. Scientists Use Online Game to Research COVID-19 Treatment. Available online: https://www.the-scientist.com/news-opinion/scientists-use-online-game-to-research-covid-19-treatment-67230 (accessed on 1 April 2020).
41. Laponogov, I.; Gonzalez, G.; Shepherd, M.; Qureshi, A.; Veselkov, D.; Charkoftaki, G.; Vasiliou, V.; Youssef, J.; Mirnezami, R.; Bronstein, M. Network machine learning maps phytochemically rich "Hyperfoods" to fight COVID-19. *Hum. Genom.* **2021**, *15*, 1–11.
42. Sadiković, S.; Branovački, B.; Oljača, M.; Mitrović, D.; Pajić, D.; Smederevac, S. Daily monitoring of emotional responses to the coronavirus pandemic in Serbia: A citizen science approach. *Front. Psychol.* **2020**, *11*, 2133.
43. Drees, J. NIH Launches COVID-19 Tracking Initiatives through 'All of Us' Precision Medicine Program. Available online: https://www.beckershospitalreview.com/data-analytics/nih-launches-covid-19-tracking-initiatives-through-all-of-us-precision-medicine-program.html (accessed on 28 April 2021).
44. Daugherty, P. Our Giant Fast-Forward. Available online: https://www.accenture.com/us-en/blogs/technology-innovation/daugherty-our-giant-fast-forward (accessed on 1 April 2021).
45. Storksdieck, M.; Shirk, J.L.; Cappadonna, J.L.; Domroese, M.; Göbel, C.; Haklay, M.; Miller-Rushing, A.J.; Roetman, P.; Sbrocchi, C.; Vohland, K. Associations for citizen science: regional knowledge, global collaboration. *Citiz. Sci. Theory Pract.* **2016**, *1*, doi:10.5334/cstp.55.

46. Haklay, M.; Fraisl, D.; Greshake Tzovaras, B.; Hecker, S.; Gold, M.; Hager, G.; Ceccaroni, L.; Kieslinger, B.; Wehn, U.; Woods, S. Contours of citizen science: a vignette study. *SocArXiv* **2020**, 10.31235/osf.io/6u2ky, doi:10.31235/osf.io/6u2ky.
47. Haklay, M.; Motion, A.; Balázs, B.; Kieslinger, B.; Greshake Tzovaras, B.; Nold, C.; Dörler, D.; Fraisl, D.; Riemenschneider, D.; Heigl, F. ECSA's Characteristics of Citizen Science: Explanation Notes. Available online: https://doi.org/10.5281/zenodo.3758555 (accessed on 20 July 2021).
48. National Academies of Sciences, Engineering and Medicine. *Learning through Citizen Science: Enhancing Opportunities by Design*; The National Academies Press: Washington, DC, USA, 2018; https://doi.org/10.17226/25183.
49. Ballard, H.L.; Robinson, L.D.; Young, A.N.; Pauly, G.B.; Higgins, L.M.; Johnson, R.F.; Tweddle, J.C. Contributions to conservation outcomes by natural history museum-led citizen science: Examining evidence and next steps. *Biol. Conserv.* **2017**, *208*, 87–97.
50. Shirk, J.L.; Ballard, H.L.; Wilderman, C.C.; Phillips, T.; Wiggins, A.; Jordan, R.; McCallie, E.; Minarchek, M.; Lewenstein, B.V.; Krasny, M.E., et al. Public participation in scientific research: a framework for deliberate design. *Ecol. Soc.* **2012**, *17*, http://dx.doi.org/10.5751/ES-04705-170229.
51. Haklay, M. Citizen Science and Volunteered Geographic Information: Overview and Typology of Participation. In *Crowdsourcing Geographic Knowledge: Volunteered Geographic Information (VGI) in Theory and Practice*; Sui, D., Elwood, S., Goodchild, M., Eds.; Springer Netherlands: Dordrecht, 2013; pp. 105–122, doi:10.1007/978-94-007-4587-2_7.
52. Herrick, J.E.; Cox, D.W.; Lundgren, B.; Nindi, S. Global citizen science for people. *Front. Ecol. Environ.* **2018**, *16*, 491–491.
53. Science Europe. Science Europe Briefing Paper on Citizen Science. Available online: https://www.scienceeurope.org/media/gjze3dv4/se_briefingpaper_citizenscience.pdf (accessed on 1 June 2020).
54. Haklay, M.; Motion, A.; Balázs, B.; Kieslinger, B.; Greshake Tzovaras, B.; Nold, C.; Dörler, D.; Fraisl, D.; Riemenschneider, D.; Heigl, F., et al. ECSA's Characteristics of Citizen Science. Available online: https://doi.org/10.5281/zenodo.3758668 (accessed on 20 July 2021).
55. PLAN4theLAND. Monitoring Reproductive Birds in Hara Protected Area with Participation of Local Community. Available online: http://plan4land.org/en/portfolio-items/monitoring-reproductive-birds-in-hara-protected-area-with-participation-of-local-community (accessed on 10 June 2020).
56. UNDP/GEF/SGP. Community Based Turtle Conservation in Qeshm Island. Available online: https://www.undp.org/content/dam/iran/docs/GEF-SGP/Marine%20and%20Coastline/Community%20based%20turtle%20conservation,%20SGP%20Iran.pdf (accessed on 10 June 2020).
57. sinapress.ir. The High Price of the Equipment is a Barrier for Amateur Astronomers. Available online: https://sinapress.ir/news/print/76770 (accessed on 10 June 2020).
58. ana.ir. Amateur Astronomy in Iran is One of the Most Advanced in the World. Available online: http://ana.ir/i/284851 (accessed on 6 June 2020).
59. Boyd, D. Pro-am collaboration in astronomy-past, present and future. *J. Br. Astron. Assoc.* **2011**, *121*, 73–90.
60. Tafreshi, B.A. Popularising astronomy in Iran. *Proc. Int. Astron. Union* **2011**, *5*, 754–757, doi:10.1017/S1743921311003139.
61. hamshahrionline.ir. How the New Crescent Moon is Observing? Available online: hamshahrionline.ir/xZfh (accessed on 10 June 2020).
62. Pourkhorsandi, H. Search for Impact Craters in Iran: Citizen Science as a Useful Method. *arXiv Prepr.* **2013**, arXiv:1307.1580 .
63. Pourkhorsandi, H.; Gattacceca, J.; Rochette, P.; d'Orazio, M.; Kamali, H.; de Avillez, R.; Letichevsky, S.; Djamali, M.; Mirnejad, H.; Debaille, V. Meteorites from the Lut Desert (Iran). *Meteorit. Planet. Sci.* **2019**, *54*, 1737–1763.
64. avastarco.com. Transit of Mercury Data Collection Project. Available online: https://avastarco.com/%D9%BE%D8%B1%D9%88%DA%98%D9%87-%D8%AF%D8%A7%D8%AF%D9%87%E2%80%8C%DA%AF%DB%8C%D8%B1%DB%8C-%D8%A7%D8%B2-%DA%AF%D8%B0%D8%B1-%D8%B9%D8%B7%D8%A7%D8%B1%D8%AF-1398/ (accessed on 10 June 2020).
65. Talezadeh, M.H. Project on Crater Timings During Lunar Eclipse (July 27, 2018). Available online: http://www.astronomers.ir/92/%D9%85%D8%AC%D9%85%D9%88%D8%B9%D9%87-%D9%BE%D8%B1%D9%88%DA%98%D9%87-%D9%87%D8%A7%DB%8C-%D8%B2%D9%85%D8%A7%D9%86-%D8%B3%D9%86%D8%AC%DB%8C-%D8%AF%D9%87%D8%A7%D9%86%D9%87-%D9%87%D8%A7%DB%8C-%D9%85%D8%A7 (accessed on 10 June 2020).
66. mehrnews.com. Commencement of the Executive Operation of Participatory Monitoring of the Nowrozlo Wetland Ecosystem. Available online: mehrnews.com/xKMHm (accessed on 10 June 2020).
67. Vahidi, H.; Klinkenberg, B.; Johnson, B.; Moskal, L.; Yan, W. Mapping the Individual Trees in Urban Orchards by Incorporating Volunteered Geographic Information and Very High Resolution Optical Remotely Sensed Data: A Template Matching-Based Approach. *Remote Sens.* **2018**, *10*, 1134.
68. iribnews.ir. Launching of the Self-Reporting System for Recording of the Blood Pressure. Available online: https://www.iribnews.ir/00ABrV (accessed on 10 June 2020).
69. pavehpress.ir. With the Wide Participation of the People, the Blood Pressure Measurement Program in Paveh County was Completed with Participation of 99.8% of Eligible People. Available online: http://www.pavehpress.ir/89292-2 (accessed on 10 June 2020).
70. isna.ir. The Recording of the Blood Pressure of over 28 Million People in the Country. Available online: https://www.isna.ir/news/98041306844 (accessed on 10 June 2020).

71. nojum.ir. The Registration of the Groups for Participation in the 4th and 5th Campaigns of “All Iran Asteroid Search” is Started. Available online: http://nojum.ir/news/%d8%aa%d8%a7%d8%b2%d9%87%e2%80%8c%d9%87%d8%a7/866/%d8%ab%d8%a8%d8%aa+%d9%86%d8%a7%d9%85+%da%af%d8%b1%d9%88%d9%87%db%8c+%d8%a8%d8%b1%d8%a7%db%8c+%d8%b4%d8%b1%da%a9%d8%aa+%d8%af%d8%b1+%da%86%d9%87%d8%a7%d8%b1%d9%85%db%8c%d9%86+%d9%88+%d9%be%d9%86%d8%ac%d9%85%db%8c%d9%86+%d8%a8%d8%b1%d9%86%d8%a7%d9%85%d9%87+%d8%ac%d9%86%d8%a8%d8%b4+%d8%a7%db%8c%d8%b1%d8%a7%d9%86%db%8c+%d8%ac%d8%b3%d8%aa%d8%ac%d9%88%db%8c+%d8%b3%db%8c%d8%a7%d8%b1%da%a9+%d8%a2%d8%ba%d8%a7%d8%b2+%d8%b4%d8%af (accessed on 10 June 2020).
72. Goodchild, M.F. Citizens as sensors: the world of volunteered geography. *GeoJournal* **2007**, *69*, 211–221.
73. WHO. Archived: WHO Timeline—COVID-19. Available online: https://www.who.int/news-room/detail/27-04-2020-who-timeline---covid-19 (accessed on 1 July 2020).
74. WHO. Timeline of WHO’s Response to COVID-19. Available online: https://www.who.int/news-room/detail/29-06-2020-covidtimeline (accessed on 1 July 2020).
75. Gharebaghi, R.; Heidary, F. COVID-19 and Iran: swimming with hands tied! *Swiss Med. Wkly.* **2020**, *150*, https://doi.org/10.4414/smw.2020.20242.
76. khabaronline.ir. Dr. Namaki at Parliament: We Have not yet Entered the Stage of Controlling of COVID-19 Disease Available online: https://khabaronline.ir/news/1373850 (accessed on 1 July 2020).
77. pana.ir. Rabiei: People follow the news about Coronavirus only from the Ministry of Health and Medical Education. Available online: http://pana.ir/news/1024898 (accessed on 1 July 2020).
78. isna.ir. Rabiei: The National Task Force for Fighting Coronavirus Will Be Established. Available online: https://www.isna.ir/news/98120100192 (accessed on 1 July 2020).
79. yjc.ir. The meeting of the National Task Force for Fighting Coronavirus was Held. Available online: https://www.yjc.ir/00URDt (accessed on 1 July 2020).
80. Salzberg, S. Coronavirus: There Are Better Things to Do than Panic. Available online: https://www.forbes.com/sites/stevensalzberg/2020/02/29/coronavirus-time-to-panic-yet/#796ddb127fa6 (accessed on 1 July 2020).
81. mehrnews.com. Covid-19 Cases Hit 978 in Iran: Official. Available online: https://en.mehrnews.com/news/156197/Covid-19-cases-hit-978-in-Iran-official (accessed on 1 July 2020).
82. WHO. WHO Director-General’s Opening Remarks at the Media Briefing on COVID-19 Available online: https://www.who.int/dg/speeches/detail/who-director-general-s-opening-remarks-at-the-media-briefing-on-covid-19---2-march-2020 (accessed on 1 July 2020).
83. mehrnews.com. Identification of 6390 New COVID-19 Cases. Available online: mehrnews.com/xTs3Q (accessed on 1 April 2021).
84. Adler, R.P.; Goggin, J. What do we mean by “civic engagement”? *J. Transform. Educ.* **2005**, *3*, 236–253.
85. Cnaan, R.A.; Park, S. The multifaceted nature of civic participation: A literature review. *Volunt. Rev.* **2016**, *1*, https://doi.org/10.1163/24054933-12340001
86. Whittaker, J.; McLennan, B.; Handmer, J. A review of informal volunteerism in emergencies and disasters: Definition, opportunities and challenges. *Int. J. Disaster Risk Reduct.* **2015**, *13*, 358–368.
87. Romano, M.; Díaz, P.; Aedo, I. Emergency Management and Smart Cities: Civic engagement through gamification. In Proceedings of International Conference on Information Systems for Crisis Response and Management in Mediterranean Countries, Madrid, Spain, 26–28 October 2016; pp. 3–14.
88. Pyles, L.; Svistova, J.; Ahn, S.; Birkland, T. Citizen participation in disaster recovery projects and programmes in rural communities: a comparison of the Haiti earthquake and Hurricane Katrina. *Disasters* **2018**, *42*, 498–518, doi:10.1111/disa.12260.
89. Wilson, J. Volunteering. *Annu. Rev. Sociol.* **2000**, *26*, 215–240.
90. Brown, E. Assessing the value of volunteer activity. *Nonprofit Volunt. Sect. Q.* **1999**, *28*, 3–17.
91. United Nations Volunteers. *Volunteerism and Disasters: An extract from the 2011 State of the World’s Volunteerism Report*; United Nations Volunteers (UNV): Bonn, Germany, 2012.
92. Fulmer, T.; Portelli, I.; Foltin, G.L.; Zimmerman, R.; Chachkes, E.; Goldfrank, L.R. Organization-based Incident Management: Developing a Disaster Volunteer Role on a University Campus. *Disaster Manag. Response* **2007**, *5*, 74–81, https://doi.org/10.1016/j.dmr.2007.06.001.
93. Baillie Smith, M. Coronavirus Volunteers Aren’t just a Source of Free Labour—Don’t Take Advantage of Them. Available online: https://theconversation.com/coronavirus-volunteers-arent-just-a-source-of-free-labour-dont-take-advantage-of-them-136103 (accessed on 1 July 2020).
94. Crawford Engagement. Bringing Volunteers Back into the Post-Coronavirus Crisis Conversation. Available online: https://crawford.anu.edu.au/news-events/news/16663/bringing-volunteers-back-post-coronavirus-crisis-conversation (accessed on 1 July 2020).
95. Marston, C.; Renedo, A.; Miles, S. Community participation is crucial in a pandemic. *Lancet (Lond. Engl.)* **2020**, *395*, 1676–1678, doi:10.1016/S0140-6736(20)31054-0.
96. Aminizade, M.; Nekouei Moghaddam, M.; Birami Jam, M.; Shamsi, M.; Majidi, N.; Amanat, N.; Hoseini, S.H. The role of volunteer citizens in response to accidents and disasters. *Health Emergencies Disasters Q.* **2017**, *2*, 107–124.

97. Larijani, B.; Zahedi, F.; Malek Afzali, H. Medical ethics in the Islamic Republic of Iran. *EMHJ-East. Mediterr. Health J.* **2005**, *11*, 1061–1072.
98. Salehi, N.; Dehghani, M. The Rich Who Have the Humility of the Poor: Effects of Culture and Power on Altruism. In Proceedings of Proceedings of the Annual Meeting of the Cognitive Science Society, Berlin, Germany, 31 July–3 August 2013.
99. Aminizadeh, M.; Mahmoodzadeh, A.; Saberinia, A.; Aminizadeh, A. The relationship of motivation factors and satisfaction of Kerman Province health volunteers in unexpected events. *J. Manag. Med. Inform. Sch.* **2014**, *2*, 65–57.
100. Twigg, J.; Mosel, I. Emergent groups and spontaneous volunteers in urban disaster response. *Environ. Urban.* **2017**, *29*, 443–458, doi:10.1177/0956247817721413.
101. Waldman, S.; Yumagulova, L.; Mackwani, Z.; Benson, C.; Stone, J.T. Canadian citizens volunteering in disasters: From emergence to networked governance. *J. Contingencies Crisis Manag.* **2018**, *26*, 394–402.
102. Takian, A.; Raoofi, A.; Kazempour-Ardebili, S. COVID-19 battle during the toughest sanctions against Iran. *Lancet (Lond. Engl.)* **2020**, *395*, 1035.
103. Dalglish, S.L. COVID-19 gives the lie to global health expertise. *Lancet* **2020**, *395*, 1189.
104. Akhondzadeh, S. Trump, COVID-19, Natural Disasters and Health in Iran. *J. Iran. Med. Counc.* **2020**, *3*, 1–1.
105. Neria, Y.; Nandi, A.; Galea, S. Post-traumatic stress disorder following disasters: a systematic review. *Psychol Med.* **2008**, *38*, 467–480, doi:10.1017/S0033291707001353.
106. World Health Organization. *Digital Tools for COVID-19 Contact Tracing: Annex: Contact Tracing in the Context of COVID-19, 2 June 2020*; World Health Organization: Geneva, Switzerland, 2020.
107. Raeisi, A.; Tabrizi, J.S.; Gouya, M.M. IR of Iran National Mobilization against COVID-19 Epidemic. *Arch. Iran. Med.* **2020**, *23*, 216.
108. irna.ir. Screening of More than 69 Million People in the National Mobilization Against COVID-19 Program. Available online: www.irna.ir/news/83737314 (accessed on 1 April 2021).
109. tabnak.ir. COVID-19 Risk Map for Tehran. Available online: tabnak.ir/0042yA (accessed on 10 June 2020).
110. irna.ir. Minister of MICT: Almost the Whole Country Has Been Affected by COVID-19. Available online: www.irna.ir/news/83710720 (accessed on 10 June 2020).
111. alef.ir. Zali: The Number of Patients in Tehran is Increasing. Available online: https://www.alef.ir/news/3981225028.html (accessed on 1 April 2021).
112. World Health Organization. *Ethical Considerations to Guide the Use of Digital Proximity Tracking Technologies for COVID-19 Contact Tracing: Interim Guidance, 28 May 2020*; World Health Organization: Geneva, Switzerland, 2020.
113. Li, T.; Faklaris, C.; King, J.; Agarwal, Y.; Dabbish, L.; Hong, J.I. Decentralized is not risk-free: Understanding public perceptions of privacy-utility trade-offs in COVID-19 contact-tracing apps. *arXiv Prepr.* **2020**, arXiv:2005.11957 .
114. ana.ir. The Mask is the only App Approved by the Ministry of Health and Medical Education. Available online: http://ana.ir/i/486320 (accessed on 5 May 2020).
115. mask.ir. Frequently Asked Questions. Available online: https://mask.ir/faq.html (accessed on 6 May 2020).
116. yjc.ir. The Mask App Currently has about One Million Active Users; It Is Recommended that Citizens Take Use of this Software seriously. Available online: https://www.yjc.ir/00Um8J (accessed on 5 May 2020).
117. dolat.ir. Measure the Risk of COVID-19 with the Mask App. Available online: http://dolat.ir/detail/336826 (accessed on 5 May 2020).
118. Mask App (@mask_application). Total Number of Active Installation of Mask App Reached Exceeded 1 Million. Available online: http://www.t.me/mask_application (accessed on 1 April 2021).
119. Machine Intelligence and Robotics Department of the University of Tehran. Can Coronavirus Disease 2019 be Diagnosed with a Cough? Available online: https://ece.ut.ac.ir/article/101190302 (accessed on 3 May 2020).
120. ana.ir. Students' App will Help in the Detection of Coronavirus Disease 2019: The Sound of Coughing is an Effective Factor in the Screening of Individuals. Available online: http://ana.ir/i/483582 (accessed on 3 May 2020).
121. China-Iran Cooperation Group against COVID-19 Disease. Available online: https://www.instagram.com/anticorona_ir (accessed on 18 May 2020).
122. irna.ir. China and Iran Fight against Coronavirus through the Transfer of Experiences. Available online: www.irna.ir/news/83706566 (accessed on 18 May 2020).
123. ifpnews.com. Iran Launches Knowledge Sharing Network for Medical Staff Fighting Corona. Available online: https://ifpnews.com/iran-launches-knowledge-sharing-network-for-medical-staff-fighting-corona (accessed on 18 May 2020).
124. Richter, A.; Dörler, D.; Hecker, S.; Heigl, F.; Pettibone, L.; Serrano Sanz, F.; Vohland, K.; Bonn, A. Capacity building in citizen science. In *Citizen Science: Innovation in Open Science, Society and Policy*; Hecker, S., Haklay, M., Bowser, A., Makuch, Z., Vogel, J., Bonn, A., Eds.; UCL Press: London, UK, 2018.
125. Vahidi, H.; Klinkenberg, B.; Yan, W. Trust as a proxy indicator for intrinsic quality of Volunteered Geographic Information in biodiversity monitoring programs. *GIScience Remote Sens.* **2018**, *55*, 502–538.
126. Krumm, J.; Davies, N.; Narayanaswami, C. User-generated content. *IEEE Pervasive Comput.* **2008**, *7*, 10–11.
127. Kosmala, M.; Wiggins, A.; Swanson, A.; Simmons, B. Assessing data quality in citizen science. *Front. Ecol. Environ.* **2016**, *14*, 551–560.
128. Goodchild, M.F.; Glennon, J.A. Crowdsourcing geographic information for disaster response: A research frontier. *Int. J. Digit. Earth* **2010**, *3*, 231–241.

129. Wyler, D.; Haklay, M. Integrating citizen science into university. In *Citizen Science: Innovation in Open Science, Society and Policy*; Hecker, S., Haklay, M., Bowser, A., Makuch, Z., Vogel, J., Bonn, A., Eds.; UCL Press: London, UK, 2018; pp. 168-181.
130. Moczek, N.; Voigt-Heucke, S.L.; Mortega, K.G.; Fabó Cartas, C.; Knobloch, J. A Self-Assessment of European Citizen Science Projects on Their Contribution to the UN Sustainable Development Goals (SDGs). *Sustainability* **2021**, *13*, 1774.
131. Commission European. Open Innovation, Open Science, Open to the World—A Vision for Europe. Available online: https://ec.europa.eu/digital-single-market/en/news/open-innovation-open-science-open-world-vision-europe (accessed on 1 April 2021).
132. Anderson, A.A.; Williams, E.; Long, M.; Carter, E.; Volckens, J. Organizationally based citizen science: considerations for implementation. *J. Sci. Commun.* **2020**, *19*, A01.
133. Takemoto, S.; Shibuya, N.; Kuek, S.C.; Keeley, A.R.; Yarina, L. *Information and Communication Technology for Disaster Risk Management in Japan : How Digital Solutions are Leveraged to Increase Resilience through Improving Early Warnings and Disaster Information Sharing*; The World Bank: Washington, DC, USA, 2019.
134. Chan, D.W.-K. A reflection on the anti-epidemic response of COVID-19 from the perspective of disaster management. *Int. J. Nurs. Sci.* **2020**, *7*, 382–385, doi:10.3389/feart.2019.00320.
135. Bowser, A.; Wiggins, A.; Shanley, L.; Preece, J.; Henderson, S. Sharing data while protecting privacy in citizen science. *interactions* **2014**, *21*, 70–73.
136. Cheung, A.S. Moving beyond consent for citizen science in big data health and medical research. *Nw. J. Tech. Intell. Prop.* **2018**, *16*, 15–40.
137. Fang, S.; Xu, L.; Zhu, Y.; Liu, Y.; Liu, Z.; Pei, H.; Yan, J.; Zhang, H. An integrated information system for snowmelt flood early-warning based on internet of things. *Inf. Syst. Front.* **2015**, *17*, 321–335.
138. Goodchild, M. Geospatial data in emergencies. In *The Geographical Dimensions of Terrorism*; Taylor and Francis: New York, NY, USA, 2014; pp. 99–104, https://doi.org/10.4324/9781315810874.
139. De Longueville, B. Community-based geoportals: The next generation? Concepts and methods for the geospatial Web 2.0. *Comput. Environ. Urban Syst.* **2010**, *34*, 299–308.
140. Schulz, S.; Stegwee, R.; Chronaki, C. Standards in healthcare data. In *Fundamentals of Clinical Data Science*; Springer: Cham, Switzerland, 2019; pp. 19–36.
141. Brooks, P.; Avera, H. Standards and interoperability in healthcare information systems: Current status, problems, and research issues. In Proceedings of Fifth Midwest Association for Information Systems Conference, Moorhead, MN, USA, 21–22 May 2010.
142. West, S.E.; Pateman, R.M. Recruiting and retaining participants in citizen science: what can be learned from the volunteering literature? *Citiz. Sci. Theory Pract.* **2016**, *1*, 1–10, https://doi.org/10.5334/cstp.8.
143. Ferretti, L.; Wymant, C.; Kendall, M.; Zhao, L.; Nurtay, A.; Abeler-Dörner, L.; Parker, M.; Bonsall, D.; Fraser, C. Quantifying SARS-CoV-2 transmission suggests epidemic control with digital contact tracing. *Science* **2020**, *368*, doi:10.1126/science.abb6936.
144. Cencetti, G.; Santin, G.; Longa, A.; Pigani, E.; Barrat, A.; Cattuto, C.; Lehmann, S.; Salathe, M.; Lepri, B. Digital Proximity Tracing in the COVID-19 Pandemic on Empirical Contact Networks. *medRxiv* **2020**, https://doi.org/10.1101/2020.05.29.20115915.
145. Gasser, U.; Ienca, M.; Scheibner, J.; Sleigh, J.; Vayena, E. Digital tools against COVID-19: taxonomy, ethical challenges, and navigation aid. *Lancet Digit. Health* **2020**, *2*, doi:10.1016/S2589-7500(20)30137-0.
146. World Health Organization. *Contact Tracing in the Context of COVID-19*; World Health Organization: Geneva, Switzerland, 2020.
147. Hinch, R.; Probert, W.; Nurtay, A.; Kendall, M.; Wymant, C.; Hall, M.; Fraser, C. Effective Configurations of a Digital Contact Tracing App: A Report to NHSX. Available online: https://github.com/BDI-pathogens/covid-19_instant_tracing/blob/master/Report (accessed on 24 August 2020).
148. Kahn, J. *Digital Contact Tracing for Pandemic Response: Ethics and Governance Guidance*; Johns Hopkins University Press: Baltimore, MD, USA, 2020; doi:10.1353/book.75831.
149. Johnson, B. Nearly 40% of Icelanders are Using a Covid App—And It Hasn't Helped Much. Available online: https://www.technologyreview.com/2020/05/11/1001541/iceland-rakning-c19-covid-contact-tracing/ (accessed on 20 September 2020).
150. Dillet, R. French Contact-Tracing App StopCovid Has Been Activated 1.8 Million Times but only Sent 14 Notifications. Available online: https://techcrunch.com/2020/06/23/french-contact-tracing-app-stopcovid-has-been-activated-1-8-million-times-but-only-sent-14-notifications (accessed on
151. alef.ir. The Latest Statistics of the Country's Population. 2019. Available online: https://www.alef.ir/news/3980516027.html (accessed on 1 November 2020).
152. Newzoo. Global Mobile Market Report 2019. Available online: https://newzoo.com/insights/trend-reports/newzoo-global-mobile-market-report-2019-light-version (accessed on 30 October 2020).
153. mehrnews.com. One Million Users Canceled their in-Home ADSL Internet Service. Available online: mehrnews.com/xS6YZ (accessed on 30 October 2020).
154. Iranian Students Polling Agency (ISPA). 69% of People who Own Mobile Phones Use Smartphones. Available online: http://ispa.ir/Default/Details/fa/2066 (accessed on 30 October 2020).
155. International Telecommunication Union (ITU). Country ICT Data (until 2018): Percentage of Individuals Using the Internet (ICT Eye). Available online: https://www.itu.int/net4/ITU-D/icteye/#/topics/2001 (accessed on 1 November 2020).
156. Sharifi-Zarchi, A. Data-Driven Approach to Prevent COVID-19. Available online: https://www.aparat.com/v/eYqWm (accessed on 30 October 2020).

157. Szinay, D.; Jones, A.; Chadborn, T.; Brown, J.; Naughton, F. Influences on the uptake of and engagement with health and well-being smartphone apps: Systematic Review. *J. Med. Internet Res.* **2020**, *22*, e17572.
158. Thorneloe, R.; Epton, T.; Fynn, W.; Daly, M.; Stanulewicz, N.; Kassianos, A.; Shorter, G.W.; Moll, S.-J.; Campbell, M.; Sodergren, S. Scoping Review of Mobile Phone App Uptake and Engagement to Inform Digital Contact Tracing Tools for COVID-19. Available online: https://psyarxiv.com/qe9b6 (accessed on 1 November 2020).
159. Gera, R.; Chadha, P.; Ahuja, V. Mobile app usage and adoption: a literature review. *Int. J. Electron. Bus.* **2020**, *15*, 160–195.
160. Geoghegan, H.; Dyke, A.; Pateman, R.; West, S.; Everett, G. *Understanding Motivations for Citizen Science*; Final report on behalf of UKEOF, University of Reading, Stockholm Environment Institute (University of York) and University of the West of England: Swindon, UK, 2016.
161. Zhou, X.; Tang, J.; Zhao, Y.C.; Wang, T. Effects of feedback design and dispositional goal orientations on volunteer performance in citizen science projects. *Comput. Hum. Behav.* **2020**, *107*, 106266.
162. Ezzaouia, I.; Bulchand-Gidumal, J. *A Model to Predict Users' Intentions to Adopt Contact-Tracing Apps for Prevention from COVID-19*; Wörndl, W., Koo, C., Stienmetz, J.L., Eds.; Springer International Publishing: Cham, Switzerland, 2021; pp. 543–548, https://doi.org/10.1007/978-3-030-65785-7_51.
163. Trang, S.; Trenz, M.; Weiger, W.H.; Tarafdar, M.; Cheung, C.M. One app to trace them all? Examining app specifications for mass acceptance of contact-tracing apps. *Eur. J. Inf. Syst.* **2020**, *29*, 415–428.
164. Williams, S.N.; Armitage, C.J.; Tampe, T.; Dienes, K. Public attitudes towards COVID-19 contact tracing apps: A UK-based focus group study. *Health Expect.* **2021**, *24*, 377–385, https://doi.org/10.1111/hex.13179.
165. Hassandoust, F.; Akhlaghpour, S.; Johnston, A.C. Individuals' privacy concerns and adoption of contact tracing mobile applications in a pandemic: A situational privacy calculus perspective. *J. Am. Med. Inform. Assoc.* **2021**, *28*, 463–471, https://doi.org/10.1093/jamia/ocaa240.
166. Walrave, M.; Waeterloos, C.; Ponnet, K. Adoption of a Contact Tracing App for Containing COVID-19: A Health Belief Model Approach. *JMIR Public Health Surveill.* **2020**, *6*, e20572, doi:10.2196/20572.
167. O'Brien, L.; Townsend, M.; Ebden, M. 'Doing something positive': Volunteers' experiences of the well-being benefits derived from practical conservation activities in nature. *Volunt. : Int. J. Volunt. Nonprofit Organ.* **2010**, *21*, 525–545.
168. Crall, A.; Kosmala, M.; Cheng, R.; Brier, J.; Cavalier, D.; Henderson, S.; Richardson, A. Volunteer recruitment and retention in online citizen science projects using marketing strategies: lessons from Season Spotter. *J. Sci. Commun.* **2017**, *16*, A01.
169. iribnews.ir. Analysis of COVID-19 Patients Data in Iran. Available online: https://www.iribnews.ir/00BDlt (accessed on 13 October 2020).
170. Rahnamoon Salamat. Official Letter of the Minister of MOHME to Director-General of IRIB for Advertising of Mask Project. Available online: https://t.me/rah_salamat/11688 (accessed on 20 October 2020).
171. iribnews.ir. Mask Application. Available online: https://www.iribnews.ir/00BG8y (accessed on 13 October 2020).
172. ana.ir. Using the Capacity of Universities in Production of "Mask app". Available online: http://ana.ir/i/484902 (accessed on 13 October 2020).
173. msrt.ir. The Necessity to Use the Sharif University's Mask App for Smart Screening of COVID-19. Available online: https://www.msrt.ir/fa/news/54255/%D8%B6%D8%B1%D9%88%D8%B1%D8%AA-%D8%A7%D8%B3%D8%AA%D9%81%D8%A7%D8%AF%D9%87-%D8%A7%D8%B2-%D8%A7%D9%BE%D9%84%DA%A9%DB%8C%D8%B4%DB%8C%D9%86-%D9%85%D8%A7%D8%B3%DA%A9-%D8%AF%D8%A7%D9%86%D8%B4%DA%AF%D8%A7%D9%87-%D8%B4%D8%B1%DB%8C%D9%81-%D8%A8%D8%B1%D8%A7%DB%8C-%D8%BA%D8%B1%D8%A8%D8%A7%D9%84%DA%AF%D8%B1%DB%8C-%D9%87%D9%88%D8%B4%D9%85%D9%86%D8%AF (accessed on 13 October 2020).
174. iribnews.ir. Introducing the Mask Application. Available online: https://www.iribnews.ir/00BEhS (accessed on 13 October 2020).
175. tv1.ir. Harf-e-Hesab/19 April 2020. Available online: http://tv1.ir/Program/143871 (accessed on 13 October 2020).
176. Mask Application. IRIB TV1-News 21:00 Interview with Dr. Ali Sharifi-Zarchi about Mask Application. Available online: https://www.aparat.com/v/xQyTa/%D9%85%D8%A7%D8%B3%DA%A9_%D8%B1%D8%A7_%D9%87%D9%85_%D8%A8%D8%B2%D9%86%DB%8C%D8%AF_%D9%88_%D9%87%D9%85_%D9%86%D8%B5%D8%A8_%DA%A9%D9%86%DB%8C%D8%AF_%7C_%D8%A7%D9%BE%D9%84%DB%8C%DA%A9%DB%8C%D8%B4%D9%86 (accessed on 13 October 2020).
177. dolat.ir. Rabiei (Government Spokesman) at the Press Conference: I Recommend all Iranians to Use the Mask Application. Available online: http://dolat.ir/video/337707 (accessed on 13 October 2020).
178. ana.ir. Mask Application is the only Application Approved by the MOHME of Iran. Available online: www.ana.press/x68yV (accessed on 13 October 2020).
179. donya-e-eqtesad.com. Harirchi Urged People to Install Mask Application on their Mobile Phones. Available online: https://www.donya-e-eqtesad.com/fa/tiny/news-3652515 (accessed on 13 October 2020).
180. javanonline.ir. The Latest Situation of the COVID-19 in the Country/29 May 2020. Available online: http://www.Javann.ir/004DQO (accessed on 13 October 2020).
181. iribnews.ir. Mask App; COVID-19 Data Analysis. Available online: https://www.iribnews.ir/00BVfp (accessed on 13 October 2020).
182. Sallis, A.; Sherlock, J.; Bonus, A.; Saei, A.; Gold, N.; Vlaev, I.; Chadborn, T. Pre-notification and reminder SMS text messages with behaviourally informed invitation letters to improve uptake of NHS Health Checks: a factorial randomised controlled trial. *BMC Public Health* **2019**, *19*, 1162.

183. Odeny, T.A.; Bailey, R.C.; Bukusi, E.A.; Simoni, J.M.; Tapia, K.A.; Yuhas, K.; Holmes, K.K.; McClelland, R.S. Text messaging to improve attendance at post-operative clinic visits after adult male circumcision for HIV prevention: a randomized controlled trial. *PLoS ONE* **2012**, *7*, e43832.
184. Goniewicz, K.; Burkle, F.M. Disaster early warning systems: the potential role and limitations of emerging text and data messaging mitigation capabilities. *Disaster Med. Public Health Prep.* **2019**, *13*, 709–712.
185. Zhang, N.; Huang, H.; Su, B.; Zhao, J.; Zhang, B. Information dissemination analysis of different media towards the application for disaster pre-warning. *PLoS ONE* **2014**, *9*, e98649.
186. Janani, L.; Motevalian, S.A. *COVID-19 Population Survey of Iran (COPPER)-Wave I.*; Iran University of Medical Sciences: Tehran, Iran, 2020.
187. qudsonline.ir. What do the Citizens of Tehran Think about COVID-19? Available online: http://qudsonline.ir/news/701455 (accessed on 1 November 2020).
188. Chih-Chung, C.; Chang, C.; Lin, L.W.-C. The effect of advertisement frequency on the advertisement attitude-the controlled effects of brand image and spokesperson's credibility. *Procedia-Soc. Behav. Sci.* **2012**, *57*, 352–359.
189. Mohseni, M.; Lindstrom, M. Social capital, trust in the health-care system and self-rated health: the role of access to health care in a population-based study. *Soc. Sci. Med.* **2007**, *64*, 1373–1383.
190. Punyanunt-Carter, N.M.; Carter, S.L. What Do Children Learn about Prosocial Behavior from the Media? *J. Am. Acad. Spec. Educ. Prof.* **2009**, *51*, 56.
191. Harrell, S.; Simons, A.; Clasen, P. Addressing Public Health Needs by Promoting Prosocial Behaviors through Social Media. Available online: https://ssrn.com/abstract=3793261 or http://dx.doi.org/10.2139/ssrn.3793261 (accessed on 20 July 2021).
192. Adzharuddin, N.A. Marketing mix through the integration of new and traditional media: a review of recent literature. *Int. J. Soc. Entrep. Innov. 2* **2013**, *2*, 3–10.
193. Finkelstein, M.A. Intrinsic and extrinsic motivation and organizational citizenship behavior: A functional approach to organizational citizenship behavior. *J. Psychol. Issues Organ. Cult.* **2011**, *2*, 19–34.
194. Ryan, R.M.; Deci, E.L. Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being. *Am. Psychol.* **2000**, *55*, 68.
195. Rotman, D.; Preece, J.; Hammock, J.; Procita, K.; Hansen, D.; Parr, C.; Lewis, D.; Jacobs, D. Dynamic changes in motivation in collaborative citizen-science projects. In Proceedings of Proceedings of the ACM 2012 conference on computer supported cooperative work, Seattle, WA, USA, 11–15 February 2012; pp. 217–226.
196. Lotfian, M.; Ingensand, J.; Brovelli, M.A. A framework for classifying participant motivation that considers the typology of citizen science projects. *ISPRS Int. J. Geo-Inf.* **2020**, *9*, 704.
197. Crimmins, T.M.; Weltzin, J.F.; Rosemartin, A.H.; Surina, E.M.; Marsh, L.; Denny, E.G. Focused Campaign Increases Activity among Participants in Nature's Notebook, a Citizen Science Project. *Nat. Sci. Educ.* **2014**, *43*, 64–72.
198. Alam, S.L.; Campbell, J. Crowdsourcing motivations in a not-for-profit GLAM context: the Australian newspapers digitisation program. In Proceedings of the 23rd Australasian Conference on Information Systems, Geelong, Australia, 3–5 December 2012.
199. Promberger, M.; Marteau, T.M. When do financial incentives reduce intrinsic motivation? Comparing behaviors studied in psychological and economic literatures. *Health Psychol.* **2013**, *32*, 950.
200. Mitchell, M.S.; Orstad, S.L.; Biswas, A.; Oh, P.I.; Jay, M.; Pakosh, M.T.; Faulkner, G. Financial incentives for physical activity in adults: systematic review and meta-analysis. *Br. J. Sports Med.* **2020**, *54*, 1259–1268.
201. Deci, E.L.; Koestner, R.; Ryan, R.M. A meta-analytic review of experiments examining the effects of extrinsic rewards on intrinsic motivation. *Psychol. Bull.* **1999**, *125*, 627.
202. Cappa, F.; Laut, J.; Porfiri, M.; Giustiniano, L. Bring them aboard: Rewarding participation in technology-mediated citizen science projects. *Comput. Hum. Behav.* **2018**, *89*, 246–257.
203. Luciano, F. Mind the app—Considerations on the ethical risks of COVID-19 apps. *Philos. Technol.* **2020**, *33*, 167–172.
204. Gneezy, U.; Meier, S.; Rey-Biel, P. When and why incentives (don't) work to modify behavior. *J. Econ. Perspect.* **2011**, *25*, 191–210.
205. Bénabou, R.; Tirole, J. Incentives and prosocial behavior. *Am. Econ. Rev.* **2006**, *96*, 1652–1678.
206. Wiggins, A.; Crowston, K. Surveying the citizen science landscape. *First Monday* **2015**, *20*, https://doi.org/10.5210/fm.v20i1.5520.
207. Aristeidou, M. *Citizen Inquiry: Engaging Citizens in Online Communities of Scientific Inquiries*; Institute of Educational Technology, The Open University: London, UK, 2016.
208. Buckingham Shum, S.; Aberer, K.; Schmidt, A.; Bishop, S.; Lukowicz, P.; Anderson, S.; Charalabidis, Y.; Domingue, J.; de Freitas, S.; Dunwell, I., et al. Towards a global participatory platform. *Eur. Phys. J. Spec. Top.* **2012**, *214*, 109–152, doi:10.1140/epjst/e2012-01690-3.
209. Bruyere, B.; Rappe, S. Identifying the motivations of environmental volunteers. *J. Environ. Plan. Manag.* **2007**, *50*, 503–516.
210. Rotman, D. *Collaborative Science across the Globe: The Influence of Motivation and Culture on Volunteers in the United States, India, and Costa Rica*; University of Maryland: College Park, MD, USA, 2013.
211. Tiago, P.; Gouveia, M.J.; Capinha, C.; Santos-Reis, M.; Pereira, H.M. The influence of motivational factors on the frequency of participation in citizen science activities. *Nat. Conserv.* **2017**, *18*, 61.
212. Liu, H.-Y.; Dörler, D.; Heigl, F.; Grossberndt, S. Citizen Science Platforms. In *The Science of Citizen Science*; Vohland, K., Land-Zandstra, A., Ceccaroni, L., Lemmens, R., Perelló, J., Ponti, M., Samson, R., Wagenknecht, K., Eds.; Springer International Publishing: Cham, Switzerland, 2021; pp. 439–459, doi:10.1007/978-3-030-58278-4_22.

213. statista.com. Number of Social Network Users Worldwide from 2017 to 2025. Available online: https://www.statista.com/statistics/278414/number-of-worldwide-social-network-users (accessed on 6 April 2021).
214. Kietzmann, J.H.; Hermkens, K.; McCarthy, I.P.; Silvestre, B.S. Social media? Get serious! Understanding the functional building blocks of social media. *Bus. Horiz.* **2011**, *54*, 241–251.
215. Obar, J.A.; Wildman, S.S. Social media definition and the governance challenge-an introduction to the special issue. *Obar, JA Wildman, S.(2015). Soc. Media Defin. Gov. Chall. Introd. Spec. Issue. Telecommun. Policy* **2015**, *39*, 745–750.
216. Warren, A.M.; Sulaiman, A.; Jaafar, N.I. Social media effects on fostering online civic engagement and building citizen trust and trust in institutions. *Gov. Inf. Q.* **2014**, *31*, 291–301.
217. Robson, C. *Using Mobile Technology and Social Networking to Crowdsource Citizen Science*; University of California, Berkeley, CA, USA, 2012.
218. Robson, C.; Hearst, M.; Kau, C.; Pierce, J. Comparing the use of social networking and traditional media channels for promoting citizen science. In Proceedings of Proceedings of the 2013 conference on Computer supported cooperative work, San Antonio, TX, USA, 23–27 February 2013; pp. 1463–1468.
219. Ambrose-Oji, B.; van der Jagt, A.P.; O'Neil, S. *Citizen Science: Social Media as a Supporting Tool*; Forest Research: Edinburgh, uk, 2014.
220. Zheng, H.; Hong, Y.; Long, D.; Jing, H. Monitoring surface water quality using social media in the context of citizen science. *Hydrol. Earth Syst. Sci.* **2017**, *21*, 949–961.
221. Liberatore, A.; Bowkett, E.; MacLeod, C.J.; Spurr, E.; Longnecker, N. Social media as a platform for a citizen science community of practice. *Citiz. Sci. Theory Pract.* **2018**, *3*, https://doi.org/10.5334/cstp.108.
222. Soysal, A.; Hooper-Bui, L.M.; Laws, E.A. Mapping and studying an urban red fox (Vulpes vulpes) population using social media. *PeerJ Prepr.* **2016**, *4*, e2623v2621.
223. Sangati, F.; Abramova, E.; Monti, J. DialettiBot: A Telegram Bot for Crowdsourcing Recordings of Italian Dialects. In Proceedings of Proceedings of the Fifth Italian Conference on Computational Linguistics CLiC-it 2018, Torino, Italy, 10–12 December 2018.

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Review

Urban–Rural Partnership Framework to Enhance Food–Energy–Water Security in the Post-COVID-19 Era

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Abstract: Food, energy, and water (collectively referred to as 'FEW') security forms the key to human survival as well as socioeconomic development. However, the security of these basic resources is increasingly threatened due to growing demand. Beyond the widespread implications on public health, Coronavirus disease (COVID-19) has further raised additional challenges for FEW security, particularly for urban populations, as they mainly outsource their FEW demands from rural areas outside their physical boundaries. In light of that, this study reviews existing literature on FEW security to highlight the growing relevance of urban–rural linkages for realizing FEW security, especially against the backdrop of the COVID-19 pandemic. To achieve this, relevant research documents have been identified through Elsevier's Scopus database and other sources (by applying search equations). The authors have accordingly underlined the necessity of shifting the conventional urban-centric approach to city region-centric development planning for the post-COVID-19 era. To this end, a framework has been suggested for translating physical urban–rural linkages to a partnership enhancing a collective response. The major elements of this framework are the conceptualization of national-level policies to support urban–rural linkages. The framework can play the role of a science–policy–action interface to redesign the FEW system in city regions.

Keywords: urban–rural partnership; food–energy–water security; global goals; sustainable development goals; COVID-19

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1. Introduction

Rapid urbanization has today become one of the major sustainability challenges worldwide, particularly in developing countries [1]. By 2018, urban areas were already the habitat of around 55% of the world's total population, a proportion due to reach 68% by 2050 [2]. Correspondingly, urban areas have emerged as the demand centers of natural resources such as food, energy, and water [3,4]. At the same time, this trend in rapid urbanization is resulting in inequality, unsustainability, polarization, and divergence in terms of development and social inclusion between urban and rural areas [5]. Due to the growing concentration of economic activities and services, cities are becoming the preferred destinations for rural migrants, wishing to pursue employment opportunities and improved quality of life [6]. Unplanned urbanization and rural-to-urban migration create various social, environmental, and sustainability challenges. A business-as-usual development approach prioritizes mainly economic and social dimensions, with environmental impacts often sidelined [7]. However, to realize sustainable development, development planning needs to be conducted through an integrated lens of economic growth, social development, and environmental conservation [8]. In the context of sustainable urbanization, managing economic prosperity and protecting the natural resources in rural regions can ensure food, energy, and water (collective referred to as 'FEW') security for urban areas [9]. Hence, the interlinkage of urban and rural has come into focus for sustainable and resilient development. A sustainable development approach, in the context of developing countries, needs to be viewed as a means of optimizing interactions between various underlying factors including poverty, climate change, rapid urbanization, and food insecurity that can make or mar socioeconomic development and environmental conservation, rather than being regarded as an ideal development pathway.

Typically, urban–rural linkages are referred to as the spatial flows of people, capital, goods, services, sectorial and financial flows, and information between rural and urban areas [10,11]. Thus, the umbrella of urban–rural linkages covers a broad variety of themes within the domain of urban and territorial planning, such as strengthening small and intermediate towns. The associated functions of social links, economic dynamics, and environmental synergies maintain the interdependencies between urban and rural areas. Encouraging an urban and rural partnership in a local context is important for realizing a transformation towards sustainable development. The importance of urban–rural partnership is, accordingly, being acknowledged in global and regional development agendas in European countries, and in development policies worldwide. For instance, Japan's 5th Basic Environment Plan recognized the necessity of urban–rural linkage for economic revitalization, and for a low carbon, and resilient society, introducing the Circulating and Ecological Sphere (CES) concept [12].

As urban populations heavily rely on rural areas for their FEW needs [13,14], the importance of urban–rural partnership has been highlighted by several studies [15–17]. Since population growth increases food demand in urban areas, the strengthening of urban–rural connections has become a determinant for food security and nutrition [18]. In parallel, the urban–rural partnership is also gaining attention, with cities declaring their commitment to the race for a net-zero emission society and capturing the potential of solar energy resources that are available in rural areas. Several cities in Europe, Japan, and other regions are now establishing a collaboration to achieve 100% renewable targets by 2050 [19,20].

Coronavirus disease 2019 (COVID-19), caused by the novel coronavirus, was first detected in December 2019, and the World Health Organization (WHO) declared the coronavirus outbreak a pandemic on 11 March 2020. In response to the pandemic, various responses have been imposed by the national and local governments that brought changes in urban–rural flows, including people's movement, food supply chain, services, etc. The widespread implications of the pandemic on human societies, beyond the implications on public health, have raised additional questions about the conventional concepts of urban development and resilience, particularly in developing countries. Taking due account of supply chain disruptions, it has been realized that urban–rural interlinkages must be carefully considered in the responses to COVID-19, and recovery strategies and actions, as well as the localization of the FEW security, should be emphasized to reboot the global economy.

A great deal of existing literature focuses on FEW sectors independently [21–23], however few studies have discussed the relationship between urban–rural partnership and the FEW nexus [24,25]. Some studies related to the FEW nexus and COVID-19 have also been published [26–28]. However, the importance of urban–rural partnerships to strengthen the FEW nexus for the post COVID-19 era has not yet been discussed. In light of that, this paper advances the current understanding of urban–rural linkages, framing them within the integrated management of FEW for the post COVID-19 era.

Mainly based on a literature review, the three key objectives of this study are: (1) To review existing literature on urban–rural linkages and their relevance for FEW security;

(2) To understand the effects of the COVID-19 pandemic on FEW security; (3) To suggest a feasible policy level framework to translate urban–rural linkages to partnership.

Overall, this paper comprises six sections. Section 2 establishes a theoretical foundation (on urban–rural linkages and FEW nexus) for the readers to better comprehend this research. Section 3 describes the adopted research methods, while Section 4 provides an overview of the research findings. Within the broader discussion of study findings, Section 5 discusses the suggested urban–rural partnership framework, and some key conclusions and research limitations are summarized in Section 6.

2. Literature Review

2.1. Significance of Urban–Rural Linkages

Urban and rural regions exist as interdependent entities connected through various spatial and sectoral flows (refer to Figure 1). Rural regions serve as centers for key resources such as food, water, energy, and labor, which are crucial for urban regions. Similarly, urban regions provide opportunities for rural dwellers, creating markets for agricultural products, and becoming sources of temporary employment and shelter. Urban–rural linkages can be defined as the direct (and two-way) flow of resources between geographically dispersed urban and rural areas [10,29,30]. Enhancing the continuity and connection between urban and rural regions is crucial for reducing poverty, achieving a satisfactory level of access to and management of resources, and at the same time maintaining the ecological and cultural diversity that is essential for regional resilience. On the other hand, unplanned and rapid urbanization is attributed to the loss of agricultural land, wetlands, and forest [25,31].

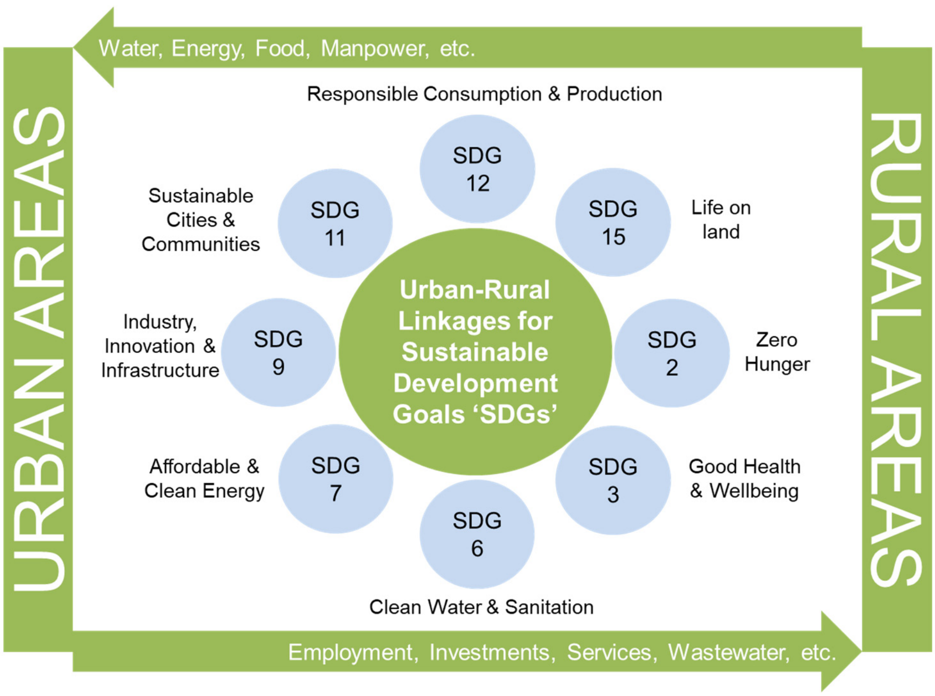

Figure 1. Conceptual diagram of urban–rural linkage with sustainable development goals (SDGs).

2.2. Urban–Rural Linkage for Achieving Global Agenda

The importance of linkages between urban and rural areas is recognized in global frameworks such as the 2030 Agenda, with its sustainable development goals (SDGs, refer to Figure 1) and the Sendai Framework for Disaster Risk Reduction, and was first acknowledged in the Vancouver Action Plan (Habitat I) [32]. The commission on Human Settlements in 1999 also appealed to consider the urban–rural interdependence in the implementation of the UN-Habitat program [33]. In 2003, the UN-Habitat emphasized urban–rural linkages in the publication "Urban-Rural Linkages Approach to Sustainable Development". At the United Nations conference in 2012, member states also committed "to work towards improving the quality of human settlements, including the living and working conditions of both urban and rural dwellers in the context of poverty eradication so that all people have access to basic services, housing, and mobility" [34]. The significance of urban–rural linkages has also been described further in the New Urban Agenda in 2016, where member states committed to supporting "the role of small and intermediate cities and towns in enhancing food security and nutrition systems, providing access to sustainable, affordable, adequate, resilient and safe housing, infrastructure and services, and facilitate effective trade links across the urban-rural continuum" [35]. This agenda has encouraged the implementation of sustainable urban and territorial planning to promote interactions among urban, peri-urban, and rural areas, in both developing and developed countries.

SDG 11—"Sustainable cities and communities" emphasizes the importance of national urban policies and regional development plans for positive economic, social, and environmental links between urban and rural areas. It calls for sustainable urbanization incorporating participatory approaches and the integration of climate change and disaster resilience into development policies and plans at all levels of settlement planning. Urban–rural interlinkages are also critical for achieving other SDGs, including SDG 2 (food), SDG 6 (water and sanitation), SDG 7 (energy), and SDG 15 (land) (as highlighted in Figure 1 earlier).

Urban–rural linkages can play an important role in mitigating the risks of both natural and man-made disasters. The Sendai Framework for Disaster Risk Reduction 2015–2030 also encourages an upgrade of knowledge on disaster risk for all possible aspects of exposure, properties of vulnerability and hazard, strengthening of disaster risk governance, and accountability for disaster risk management [36]. Urban–rural linkages can support modifying the situation of disasters in rural areas and can help minimize the vulnerability of rural residents [37]. Moreover, many development agencies, such as the Organization for Economic Cooperation and Development [38], the Department for International Development [39], and the World Bank [40] are now placing urban–rural linkage in their investment projects, thereby recognizing poverty mitigation and achieving broader equality.

2.2.1. Urban–Rural Partnership to Implement Regional Development Plan (EU Rurban Program)

Agreed by the European Parliament in 2010, RURBAN refers to the actions for sustainable urban–rural development and partnerships, managed by the European Commission. The European Union (EU) has given due importance to urban–rural linkages while working together with other countries and regions on the understanding that stronger urban–rural linkage is more beneficial in terms of more efficient land use and planning, efficient services, and sustainable natural resource management. Herein, the urban–rural partnership is increasingly being considered as a tool for regional development to replace the conventional policies of discrete urban and rural development. Starting from the second half of the 1990s, the EU has also raised awareness on urban–rural partnership through specific research programs such as Study Programme on European Spatial Planning (SPESP), European Spatial Planning Observation Network (ESPON), and the 6th Research Framework Program. Consequently, several national level initiatives have emerged to promote urban–rural partnerships in European countries such as Germany, the UK, France, and Spain.

It has been realized that urban–rural partnerships cannot be established without engaging local actors. This is because the process and outcomes are influenced by local and regional conditions. The EU has highlighted the urban–rural partnership as a specific form of governance for integrated territorial development. Primarily, such partnerships are set on a sub-regional level that is supported by a regional and national–legal and financial framework. Nevertheless, the EU provided major value to promote urban–rural partnerships depending on the community objective of economic, social, and territorial cohesion. Urban–rural partnerships were put forward in a rather new and challenging dimension, distributing the policy and funding of European cohesion and rural development to member states and regions. The EU framework requires specific methods to incorporate urban–rural issues into future programs. However, the EU administrative bodies were reluctant to include new strategic issues or governance approaches to complement urban–

rural partnerships using a certain tool for experimentation, innovation, capitalization, and developing policy.

2.2.2. Urban–Rural Linkage in the Basic Environment Plan of Japan

Against the backdrop of recent global policy agreements such as the 2030 Agenda for Sustainable Development, the 5th Basic Environment Plan was approved by the Ministry of Environment of Japan (MOEJ) in 2018. The two main ideas outlined in this plan are respect for planetary boundaries and urgent achievement of the SDGs [41]. Therefore, MOEJ introduced the CES concept in its plan for a sustainable transition. This concept is an integrated policy approach that includes three principal elements: (1) a low-carbon society, (2) resource circulation, and (3) living in harmony with nature. These elements were proposed in *Becoming a Leading Environmental Nation in the 21st Century—Japan's Strategy for a Sustainable Society* in 2007. For this, a framework was established within the CES to promote the interaction and cooperation of the three elements. The concept of a circular economy and low-carbon society is built on the ideas of reducing waste, producing renewable sources of energy, and employing ecosystem services without any damage which ultimately optimizes human activities and minimizes their impact on nature [42]. The CES encourages spatial linkages to establish advanced methods for sustainability and integrated responses at a local scale, which are in contrast to existing approaches. There are four approaches to execute the CES: (1) urban–rural linkages, (2) ecosystem-based solutions, (3) decarbonization, and (4) resource circulation.

The CES concept motivates the formation of intricate and more sustainable urban–rural linkages based on the current flows of food, goods, people, capital, waste, natural resources, and renewable energy. These strengthened linkages are intended to carry potential revised chains of ecological production and consumption in such a way that cities and towns can meet their primary resource demands within regional boundaries and become self-sufficient for energy and food while reducing waste [43].

2.3. Urban–Rural Linkage for Optimization of FEW Nexus

The FEW nexus refers to the tight interconnection between food, energy, and water systems. Furthermore, the security of each of the independent resources is reliant upon the realization of the overall FEW security. Nevertheless, demand for FEW in urban areas is met through both local in-boundary and, to a larger extent, transboundary production [44], and this rising urban demand has far-reaching environmental impacts, from in-boundary to outside of urban area boundaries. Accordingly, there is a need to optimize the production and supply of FEW resources to urban areas, at both city in-boundary and transboundary scales. A potential approach to realize this could be the evaluation of trade-offs and co-benefits among environmental effect categories, which can be inferred through water and energy footprints [44]. Water footprints inform on water removal from watersheds, risk of water scarcity in the operation of industries or power plants, and risks to crop production. This type of evaluation of trade-offs enables sufficient measures to be taken at a suitable level in four key categories to gain water security: (1) changes in FEW demand, (2) in-boundary versus transboundary FEW supply relocation, (3) intervention of in-boundary production system, and (4) intervention in trans-boundary production along with cross-sectoral food, energy, and water interactions. Execution of these measures requires interventions in supply–demand governance, integrated energy planning, integrated use planning, technological interventions, lifestyle change, and ways to engage citizens in the decision-making process at the urban–rural functional region level.

3. Research Methods

For reviewing the state-of-the-art scientific literature related to urban–rural partnership and FEW security, two major sources are considered. The first is peer-reviewed literature identified through the Elsevier's Scopus data: The search was performed with keywords 'Food, Energy, Water, Security, Urban, Rural' in the 'ALL' category, and a total of 39 literature were retrieved initially (on 22 March 2021). Another search was performed on the same date with the keywords 'Food, Energy, Water, Security, COVID-19′ in the 'ALL' category, and a total of 38 documents were found. After a manual screening of literature titles, abstracts, and sometimes full papers, the relevant documents were extracted for review. The second source is grey literature identified through other sources: Beyond the Scopus search for peer-reviewed literature, other online and offline sources were also considered to identify relevant (and up-to-date) research documents, such as government documents and reports, international organization documents and reports, conference proceedings, and newspapers. Similar keywords to those used for Scopus were also applied to other search engines (including Google Scholar), thereby identifying relevant documents to gain a better understanding of the subject and on the impacts of the COVD-19 pandemic.

4. Growing Relevance of Urban–Rural Linkage for FEW Security

4.1. Urban–Rural Linkage for Food Security

Rapid urbanization is reshaping the land-use pattern in functional urban–rural regions, which increases the challenges of achieving the global goal for zero hunger (SDG-2). Urbanization plays a significant role in increasing the demand for agricultural products in terms of both the growing population and dietary changes, which may increase risks to food security both for urban and rural populations [45]. Rural agricultural production is the major source of food for people living in contiguous urban–rural areas [46]. Loose interconnections between urban and rural areas have a negative effect on food security and nutrition for vulnerable people in cities and rural communities [47,48]. Strengthening the urban–rural linkage is one of the keys to mitigating the risk of food insecurity. Furthermore, strengthened urban–rural linkages can support inclusive economic growth by connecting rural agricultural production with urban markets, creating food supply chain-related, non-farm business and job opportunities in rural, peri-urban, and urban areas, and promoting urban technical support and investments in farms located in rural areas. Changes in the dietary choices of the urban population also influence crop cultivation. To mitigate these concerns and to strengthen urban–rural linkages, especially against the backdrop of pandemic emergencies, there is a need for city–region level responses, several examples of which are highlighted in Table 1.

Table 1. Examples of city–region food system approaches in response to pandemics.

City	City Region Food System Approach	Source
Antananarivo, Madagascar	Mapping of food flow, regulating product quantities along with discovering the importance of each actor in the food chain.	[49]
Medellín, Colombia	In response to the COVID-19 crisis, the territorial position and the city region food systems notion have been incorporated in the city's food and nutrition security programs.	[50]
Colombo, Sri Lanka	CRFS has been introduced to ensure communities can easily access food by any alternative supply chain linkages by synchronizing with multi-stakeholders across administrative boundaries.	[51]

The impact on food systems due to the COVID-19 pandemic calls attention to the opportunities that can be captured by connecting local production and consumption. Cities and wider regions need to have an action plan for helping resilient food systems, ensuring that: (1) the food supply chain is diversified and resilient to future shocks, (2) food access is maintained, and (3) mitigation is in place for vulnerable food system actors, which include small-scale producers, migrant labors, low-income, and neglected groups.

4.2. Urban–Rural Linkage and Energy Security

Huge investment is required for electricity production, and these are highlighted when moving towards decarbonized cities and industrial activity and managing investment for renewable options. Renewable technologies provide an edge over fossil fuel options as they produce little or no air pollution and can be utilized instantly. Renewable technologies are also economically helpful. The cost of electricity that solar photovoltaics and offshore wind generate is competitive with fossil power, resulting in costs being cut by 25–40% between 2018 and 2023 [52]. Renewable energy has become an essential part of the solution towards a net-zero emission world. Today, there are more than 100 cities globally that are mainly powered by renewable energy, most of which are in Africa, Europe, North America, and South America. Among these 100 renewable cities, only Inje in the Republic of Korea is located in Asia. Many other cities across the world have set a target to achieve a 100% renewable energy supply by 2050. Achieving 100% renewable energy within city territory is challenging considering the limited available space and lack of natural resources. Therefore, many cities (several examples shown in Table 2) are now building partnerships with neighboring or far distant rural areas for achieving a 100% renewable supply [53].

Table 2. Urban–rural partnership for achieving renewable energy target of selected cities.

City	Country	Vision	Urban–Rural Partnership
Barcelona	Spain	An energy-independent city through achieving 100% renewable energy (RE) by 2050	In light of the limited resources and opportunities at the city level, the municipality coordinates with the wider metropolitan area to achieve the 100% RE vision by 2050.
Frankfurt	Germany	100% RE by 2050 50% energy savings 25% RE generation within the city territory 25% RE produced in the region (metropolitan area)	It is difficult for the city of Frankfurt to achieve its "100% renewable" target on its own. It needs resources from the metropolitan area and even regional level for wind power and biomass.
Frederikshavn	Denmark	100% RE by 2030	The objective of 100% RE cannot be achieved without transforming the resources to the energy available in the surrounding area of Frederikshavn. Biomass is considered as an opportunity to boost agriculture while it develops as an energy supplier. Off-shore wind power is also tackled through DONG Energy.
Geneva	Switzerland	100% RE by 2050	To explore the locally available wood biomass, the municipality contributed to establishing a local industry, where benefits come through municipal forestry and from a partnership with the Geneva Association of private forest owners to ensure that the selling price of wood biomass is fair. This partnership ensures private owners' sustainable and free-of-charge management of forests. It promotes job opportunities in the local area.
Yokohama	Japan	Achieve carbon neutral by 2050 8% RE produce within city 92% RE supplied from outside of the city	Yokohama has concluded agreements on RE with 12 municipalities including Kuji City, Ninohe City, Kuzumaki Town, Fudai Village, Karumai Town, Noda Village, Kunohe Village, Hirono Town and Ichinohe Town, Aizuwakamatsu City, and Koriyama City, which have abundant renewable resources based on CES concept.

Among the listed cities in Table 2, Yokohama City in Japan and Frankfurt City in Germany have set targets to achieve 100% RE by 2050 through a combination of energy use efficiency improvement and increased energy supply from renewable sources. However, both these cities have limited resources within the city boundaries to ensure 100% RE generation in the city region. For example, it is estimated that Yokohama needs to receive

19.1 billion KWh in energy supply from renewable sources to achieve the ambitious carbon neutral target by 2050. However, estimates have revealed that only 8% of the total energy demand can be produced within the city boundary. Therefore, Yokohama needs to secure the remaining 92% from outside of the city area through collaboration with other cities, towns, and villages, which have abundant RE resources. Yokohama has accordingly signed agreements with 12 local governments in the Tohoku region with abundant RE sources. Under these agreements, the partner cities, towns, and villages supply RE to Yokohama City. This collaboration has helped create a circulating and ecological sphere to generate a positive economic cycle, including RE and environmental value. Similarly, the city of Frankfort has established collaboration with stakeholders in the city area, harnessing RE potential beyond the city boundary that can cover 184% of its power needs by 2050 [54]. This cooperation opens up new opportunities to convert cities and regions from energy consumers to RE prosumers, thereby creating value.

4.3. Urban–Rural Linkage and Water Security

Due to rapid urbanization, the demand for water for urban populations is projected to increase by 50–80% by 2050 [55]. To meet the growing urban water demand in the face of declining freshwater availability, the most common response is water reallocation from rural to urban regions. The increase in such trends implies that there are growing conflicts between cities and their surrounding rural areas, particularly in the global south [56,57]. A survey identified at least eight important issues that need urban–rural cooperation, including water allocation, water quality, flood control, water allocation, wastewater treatment, physical accessibility to a water source, water storage, provision of water services, and ownership of water [58]. In light of that, urban–rural collaborations can offer a win-win solution for water security at the regional level. Several good examples of urban–rural partnerships for water management and security have been identified in different places (Table 3). These include water use efficiency improvement in agriculture (e.g., Southern California in the US, Reus in Spain), improving groundwater recharge (e.g., Kumamoto in Japan), managing water source forest (Kanagawa in Japan), and promoting environment-friendly organic agricultural practices (Munich in Germany). Introducing incentive mechanisms can enhance urban–rural cooperation on water management and water security. Urban–rural cooperation can also generate multiple benefits for both sides, including water security for urban populations and increased incomes for rural people, as well as creating new job and business opportunities.

4.4. Impact of COVID-19 on FEW Nexus

Since 2020, the world has been facing the devastating effects of the COVID-19 pandemic, which has had a direct impact on FEW security [26–28] in terms of both demand-side and supply-side disruptions (overview presented in Figure 2). For instance, nearly 2.1 billion people worldwide already lacked access to safely managed drinking water [59], and so frequent handwashing has emerged as a constrained resource when trying to follow the World Health Organization's advisory on hygiene. In the case of demand-side disruptions, increased hygiene habits and medicalization has led to increased medical waste generation, which may have significant impacts on soil or water pollution if not properly treated. The treatment of additional medical waste or wastewater also requires more energy supply [60–63]. Water is further considered as the key component to fight against COVID-19 globally, as countries that lack chemical-based disinfectant depend more on a water source [64,65]. The water ecosystem is also greatly affected by biomedical waste, and this is hampering water supply sources and ultimately harming the environment [66]. In Bangladesh, at least 14,500 tons of waste from healthcare was generated across the country due to COVID-19 in April 2020 [67]. India also experienced a 46% increase in COVID-19-related biomedical waste generation in between April and May 2021, with many municipalities of India recording a sharp increase (up to 25%) in domestic water consumption (e.g., Kozhikode in Kerala and Ahmedabad in Gujarat) [68].

Table 3. Urban–rural cooperation for water management and water security.

Location	Issues	Mechanism of Collaboration	Benefits
Southern California, US	Water stress and vulnerability to drought	San Diego city-initiated agreement to give compensation to the farmers for water conservation	Nearly 100 million cubic meters (MCM) were saved by farmers and sent to the city. It is target is 237 MCM by 2021
Reus, Spain	Water allocation problem between cities and agriculture	A water market mechanism was introduced by the irrigation subscriber association that includes the Reus city, other municipalities, and small rural landowners. The water right is distributed based on fixed price	- Reduced urban water demand - Increased water use efficiency in agriculture - Revenues are used to finance dams and other infrastructures
Kumamoto, Japan	Kumamoto City, which completely relies on groundwater resources faced groundwater level depletion	Incentivizing paddy field owners for groundwater recharge	- Increased groundwater recharge that improved water security for the city - Improved income of paddy field owners
Kanagawa, Japan	Water quality of major water source rivers of prefectural water is being affected due to poor management of water source forest	Introduced conservation and restoration of water source environment through taxation and this revenue is used for supporting management water catchment areas in the upstream	- Improved quality of river water quality - Support for local forest businesses - Creates jobs in forest management sector
Munich, Germany	The city water supply source, the Mangfall valley, experienced nitrate and pesticide pollution due to intensive agricultural practices	The municipal water utility introduced a voluntary payment scheme to promote organic farming	- Improved water quality (nitrate concentration reduced to 7 mg/L) - Reduced water treatment cost - Large market for organic farming in Germany

Food security is also under stress due to widespread disruptions along the supply chain, as well as impacts on agricultural production due to mobility restrictions [69,70]. Demand-side disruptions include reduced mobility, dietary changes, reduction in industrial operations, and quarantine regulations, and these force people to take a local production approach. This implies that the FEW nexus at the local level should be assessed and optimized to avoid tradeoffs. If local production is to increase, then more water and energy will be required from local sources.

Demand-side disruptions such as a reduction in everyday mobility for work or social events results in low energy demand. Decreased leisure activities are also responsible for lowering energy demands. Lockdowns are expected to further disrupt energy demands significantly as primary energy consumption decreased [71]. It has been reported in some European countries that energy demand fell during the first wave of COVID-19 [72]. The pandemic also affected tourism, also resulting in lower demands for energy along with food and water. On the other hand, quarantine regulations may result in higher electricity and water requirements. These kinds of measures influence the overall FEW resource consumption profile.

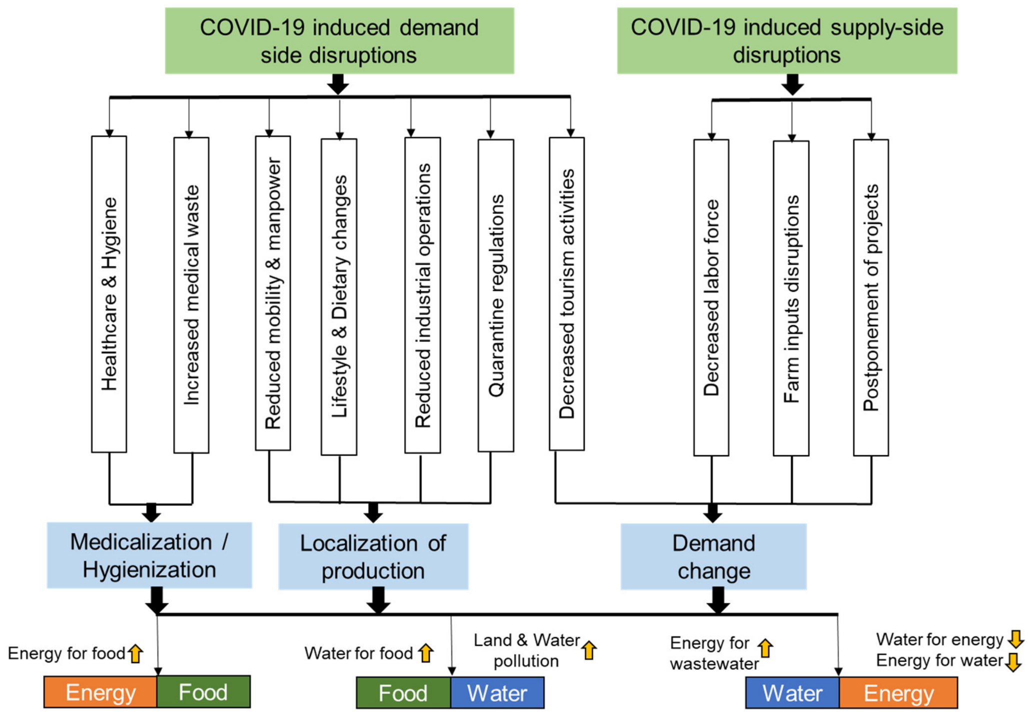

Figure 2. Implications of COVID-19 on the FEW nexus (image source: modified from [26]).

The cross-linking perspective of COVID-19 and FEW nexus is also considered to prioritize links to reduce the complexity of disruptions. Increased hygiene activities and biomedical waste has an effect on the two sub-nexuses: the food–water sub-nexus due to pollution of the land and, consequently, the water sources, and the energy-water nexus due to increasing demand for water and energy for wastewater treatment. On the other hand, disruptions due to decreased mobility and dietary changes during quarantine are forcing basic supplies to be produced locally [73–75]. This impact points to crosslinks between COVID-19 and both the food–water sub-nexus and the energy–food sub-nexus, as enhanced local food policies require water and energy. There are also other disruptions that will result in changes in the demand for water or energy resources. For example, staying at home increases electricity and water demand [76]. With the increased energy demand, energy management systems are increased. Due to this kind of instability, it is difficult to assume what the exact COVID-19-related changes are in terms of water use for electricity supply.

5. Discussion

5.1. Strengthening Urban–Rural Linkages for FEW Security in Post-COVID-19 Era

From this review of existing literature, we can conclude that the importance of FEW security is increasingly being recognized at policy and governance levels, although at varying levels and sectoral considerations. It is also being recognized that cities are increasingly reliant on their surrounding rural areas for FEW supplies [77]. For instance, in terms of energy security, it is underlined in Section 4.2. that most cities cannot achieve net-zero emission within their city boundary. While nearly 60% of the world's population lives in cities (that occupy only 2% of land area) [35], in-boundary FEW production is constrained due to high density and limited space. On the other hand, peri-urban and rural areas often lack the infrastructure they require, including human, financial, and technical resources to ensure an optimal use of regional natural resources.

As highlighted in Section 2, the importance of urban–rural linkages and FEW resource security (such as water for all, clean energy, and food security) has, accordingly, been acknowledged on global agendas, in regional programs, and for national development strategies. As discussed in Section 4.1, urban–rural linkage plays a very important role for food security, particularly in times of emergency. Enhancing local production and local consumption can thus improve resilience for food supply systems against the various externalities such as disruptions during pandemics. In response to the food supply risk due to the COVID-19 pandemic, a city–region food system approach has been promoted in different parts of the world (see Section 4.1). This approach clearly acknowledged the critical role of urban–rural linkages in mitigating food insecurity during emergencies.

Global leaders are working together, aiming for a net-zero emission world by mid-century, and, as such, a huge expansion of renewable energy (RE) would play a vital role in achieving this goal. As cities account for 70% of the world's energy consumption, actions in and by cities have received special attention for achieving important global goals and national development targets. In fact, more than 700 cities have made a wide range of commitments for achieving carbon neutral or net-zero emission targets by 2050 [78]. Achieving these commitments requires radical decarbonization measures such as achieving 100% RE, which, in many cases, go beyond city boundaries. Cities need to explore collaboration with surrounding rural areas to utilize the maximum potential of available decarbonization options that can be the engine to achieve net-zero emission. As discussed in Section 4.2, several cities in developed countries have realized that they must collaborate with rural areas if they want to achieve their 100% RE energy targets. This can generate a positive economic cycle, linking RE and environmental values. Urban–rural partnerships for the expansion of RE can also bring new job opportunities. Grid-connected renewables are mainly located outside of cities, which can create new job opportunities in rural areas. It is estimated that the RE sector will create nearly 300,000 new job opportunities in India by 2022 [79]. In particular, RE power plants can create permanent job opportunities for those people who migrated to rural are due to the pandemic [80].

While poor water management in terms of both water use efficiency and water environment conservation are some causes of increased water insecurity worldwide, Section 4.3 shows how collective urban–rural actions can help to improve water management in different regions. Cities need to secure reliable and quality water supply for their growing populations, as well as for fueling economic activities. Offering economic incentives can enhance improvements in water use efficiency and water environment conservations in rural communities, as observed in the cities of San Diego in US, Kumamoto in Japan, Reus in Spain, and Munich in Germany (refer to Table 3).

Broadly, FEW security is inherently inter-linked and inter-dependent. Overlooking the nexus that exists for FEW resources management in rural areas not only aggravates the risk to FEW sectors in those areas, but it also creates threats to FEW security for urban populations. Furthermore, the COVID-19 pandemic also places additional concerns on the FEW nexus, as responses to the pandemic have direct impacts on FEW due to disruption on both supply and demand side, as discussed in Section 4.4. In the post-COVID-19-era, more emphasis should be put on the localization of FEW security and resilience to mitigate such risks in the future. There is also likely to be an increased demand for local ecosystem services related to FEW due to intensive economic activities and demography changes. This implies that the dynamics of the FEW nexus will also change along with promotion of localization. Therefore, the local-level FEW nexus, particularly in the urban–rural continuum, is likely to also gain more attention in the post-COVID-19 era.

Here lies an opportunity to create a win–win relationship between urban and rural areas toward a self-reliant and resilient region. Cities can take advantage of the abandoned natural resources available in rural areas to meet the growing demand for FEW for their population. On the other hand, a city can offer necessary support for better management of the FEW nexus in rural areas in order to ensure an efficient and optimum use of resources for higher productivity. This can also generate multiple benefits for rural populations, including inclusive economic growth and new job opportunities.

5.2. Framework for Translating Urban–Rural Linkage to Partnership

In the post-COVID-19 era, building urban–rural partnership is essential to formulate a sustainable recovery plan for FEW systems and to redesign these systems. This can be achieved by acknowledging the interdependence of urban and rural areas, thereby optimizing the FEW nexus.

Conventional urban and rural governance is designed for the management of issues and challenges within a specific area's own spatial boundaries only, and underestimates the value of surrounding landscapes for their resilience and sustainable development. Ignorance of urban–rural linkages in the national legislation and policies is also one of the main reasons for the disconnected management of FEW resources. In recent years, urban–rural linkages have been strengthened in some developed countries or regions, with national governments and regional authorities formulating strong supporting policies. For example, urban–rural linkages have been promoted in some of Japan's major government policy documents such as its Basic Environmental Plan. Furthermore, several supporting schemes have been launched to promote urban–rural linkages. As discussed in Section 2, urban–rural partnerships have also been promoted by the European Union with various supporting schemes, and many European countries have established good practices in urban–rural linkages that can serve as guidance for developing countries. This implies that national governments should take proactive steps to promote urban–rural partnership by formulating appropriate legislation, strategic guidelines, and relevant policies, as well as by offering technical and financial assistance.

These national-level interventions are expected to trigger cooperation initiatives between urban and rural governments. Upscaling the sustainability of urban–rural cooperation requires a platform that brings together all key stakeholders from urban–rural regions to ensure horizontal coordination and to formulate a common vision and integrated actions for a sustainable FEW system. This platform can play the role of a science–policy–action interface by connecting people, skills, and money from the city region. Strengthened urban–rural partnerships will lead to a collective response to address disruptions in the system, formulation of integrated recovery policies, and a redesign of FEW systems through the optimum use of local resources, skills, and finance. A strong urban–rural partnership will not only enhance the resilience of the city region, but will also contribute to the localization of national and global goals. Figure 3 illustrates a suggested framework for enhancing urban–rural partnerships.

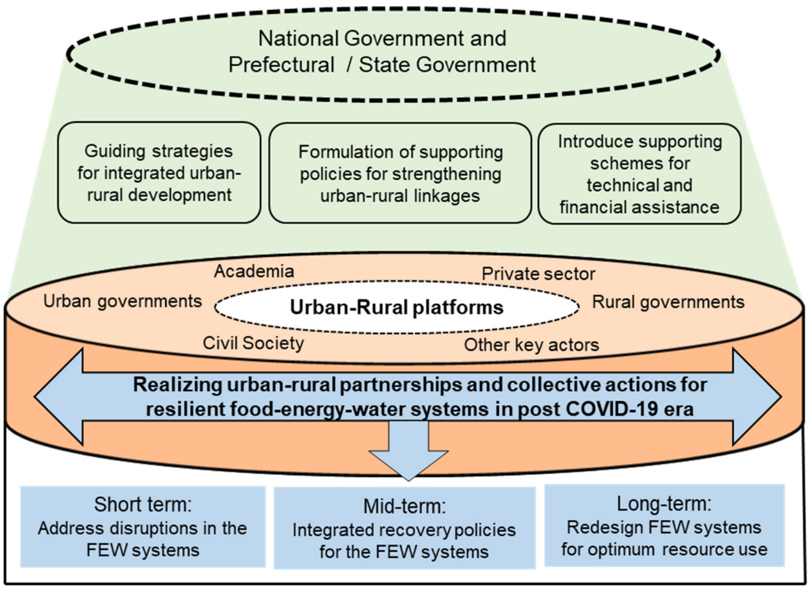

Figure 3. Framework of urban–rural partnership for capturing multiple benefits (image source: authors).

6. Conclusions

This study highlights the importance of strengthening urban–rural linkage for the collective security of FEW in the post-COVID-19 era. Based mainly on a review of the existing literature, this study develops a precise understanding of the importance of urban–rural linkages and sets out a city-region perspective for FEW security. It also synthesizes the impact of COVID-19 measures on the FEW nexus, for disruption to both demand and supply, discussing how the pandemic and various countermeasures have altered the relationship across the FEW nexus. A framework on how to translate urban–rural linkages into partnerships has also been suggested to manage FEW systems in a collective manner. The important elements of the proposed framework are the formulation of national-level policies to support urban–rural linkages, the provision of guidance and technical and financial assistance through national schemes, and the engagement of multistakeholder platforms at a city-region level. Multistakeholder platforms can play a role as science–policy–action interfaces that enhance the collective response, sustainable recovery plans, and the redesign of the food, energy, and water nexus in an urban region.

To meet the increasing demand for FEW by rapidly growing populations is challenging, particularly for urban areas that mostly rely on supply from outside of city boundaries. Hence, urban–rural linkages should be properly acknowledged for enhancing the security of FEW resources. This study found that existing literature highlights the application of urban–rural linkage for FEW security, however focuses on a single or dual resource security issue. While FEW security is interlinked, this study argues for collectively managing the FEW nexus both on the supply side (rural areas) and demand side (urban areas) through strengthening urban–rural linkages.

The authors acknowledge that this research is subject to certain limitations, as it is mainly based on a review of existing literature. Although the study findings are expected to remain relevant for the long term, the situation surrounding the COVID-19 pandemic is changing constantly, and a growing number of studies are further highlighting good examples of FEW security from around the world. The future scope of this research accordingly entails case-specific studies at a local level, wherein the applicability of the proposed framework for translating urban–rural linkages into partnerships can be tested.

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References

1. World Risk Report. Available online: https://i.unu.edu/media/ehs.unu.edu/news/4070/11895.pdf (accessed on 20 August 2021).
2. United Nations. *World Urbanization Prospects 2018: Highlights*; Department of Economic and Social Affairs Population Division: New York, NY, USA, 2019.
3. Vogt, C.; Zimmermann, M.; Brekke, K. Operationalizing the Urban Nexus. Towards Resource-Efficient and Integrated Cities and Metropolitan Regions. GIZ and ICLEI. 2014. Available online: https://www.thegpsc.org/sites/gpsc/files/urbannexus_publication_iclei-giz_2014_kl_0.pdf (accessed on 26 September 2021).
4. Covarrubias, M. The nexus between water, energy and food in cities: Towards conceptualizing socio-material interconnections. *Sustain. Sci* **2019**, *14*, 277–287. [CrossRef]
5. Habitat, U.N. Implementing the New Urban Agenda by Strengthening Urban-Rural Linkages. In *Leave No One And No Space Behind*; UN Habitat: Nairobi, Kenya, 2017.
6. Naudé, W. The Determinants of Migration from Sub-Saharan African Countries. *J. Afr. Econ.* **2010**, *19*, 330–356. [CrossRef]
7. Chan, P. Assessing Sustainability of the Capital and Emerging Secondary Cities of Cambodia Based on the 2018 Commune Database. *Data* **2020**, *5*, 79. [CrossRef]
8. Cobbinah, P.B.; Erdiaw-Kwasie, M.O.; Amoateng, P. Rethinking sustainable development within the framework of poverty and urbanisation in developing countries. *Environ. Dev.* **2015**, *13*, 18–32. [CrossRef]
9. Hussein, K.; Suttie, D. *Rural-Urban Linkages and Food Systems in Sub-Saharan Africa: The Rural Dimension*; IFAD: Rome, Italy, 2016.
10. Tacoli, C. Rural-urban interactions: A guide to the literature. *Environ. Urban.* **1998**, *10*, 147–166. [CrossRef]
11. Braun, J.V. Rural-urban linkages for growth, employment, and poverty reduction. In Proceedings of the Fifth International Conference on the Ethiopian Economy, Addis Ababa, Ethiopia, 7–9 June 2007.
12. Ministry of Environment Japan. The 5th Basic Environment Plan. Available online: https://www.env.go.jp/policy/kihon_keikaku/plan/plan_5/attach/ref_en-02.pdf (accessed on 27 August 2021).
13. Jennings, S.; Cottee, J.; Curtis, T.; Miller, S. Food in an urbanised world: The role of city region food systems in resilience and sustainable development. In Proceedings of the Report on Food in an Urbanized World Conference, London, UK, 4 February 2015.
14. Gebre, T.; Gebremedhin, B. The mutual benefits of promoting rural-urban interdependence through linked ecosystem services. *Glob. Ecol. Conserv.* **2019**, *20*, e00707. [CrossRef]
15. Mitra, B.K.; Shaw, R.; Yan, W.; Takeda, T. Water-Energy-Food Nexus: A Provision to Tackle Urban Drought. In *Urban Drought Disaster Risk Reduction (Methods, Approaches and Practices)*; Ray, B., Shaw, R., Eds.; Springer: Singapore, 2019; pp. 69–86.
16. Sukhwani, V.; Deshkar, S.; Shaw, R. COVID-19 Lockdown, Food Systems and Urban–Rural Partnership: Case of Nagpur, India. *Int. J. Environ. Res. Public Health* **2020**, *17*, 5710. [CrossRef]
17. Asian Development Bank. *Transforming Urban-Rural Water Linkages into High-Quality Investments*; Asian Development Bank: Manilla, Phillipines, 2020.
18. Graziano da Silva, J.; Fan, S. Smallholders and urbanization: Strengthening rural-urban linkages to end hunger and malnutrition. In *2017 Global Food Policy Report*; International Food Policy Research Institute (IFPRI): Washington, DC, USA, 2017; pp. 14–23. [CrossRef]
19. International Energy Agency. Energy Policy Review. Available online: https://www.iea.org/reports/european-union-2020 (accessed on 12 June 2021).
20. City of Yokohama. Realization of Transition to 100% Renewable Energy at New Yokohama City Hall Building. Available online: https://www.city.yokohama.lg.jp/lang/overseas/climatechange/news/cityhallre100.files/0001_20200731.pdf (accessed on 2 September 2021).
21. Yang, H.; Zhou, Y.; Liu, J. Land and water requirements of biofuel and implications for food supply and the environment in China. *Energy Policy* **2009**, *37*, 1876–1885. [CrossRef]
22. Bogardi, J.J.; Dudgeon, D.; Lawford, R.; Flinkerbusch, E.; Meyn, A.; Pahl-Wostl, C.; Vielhauer, K.; Vörösmarty, C. Water security for a planet under pressure: Interconnected challenges of a changing world call for sustainable solutions. *Curr. Opin. Environ. Sustain.* **2012**, *4*, 35–43. [CrossRef]
23. Karimi, P.; Qureshi, A.S.; Bahramloo, R.; Molden, D. Reducing carbon emissions through improved irrigation and groundwater management: A case study from Iran. *Agric. Water Manag.* **2012**, *108*, 52–60. [CrossRef]
24. Sukhwani, V.; Shaw, R.; Mitra, B.K.; Yan, W. Optimizing Food-Energy-Water (FEW) Nexus to Foster Collective Resilience in Urban-Rural Systems. *Prog. Disaster Sci.* **2019**, *1*, 100005. [CrossRef]
25. Sukhwani, V.; Shaw, R. A Water-Energy-Food Nexus based Conceptual Approach for Developing Smart Urban-Rural Linkages in Nagpur Metropolitan Area, India. *J. Integr. Disaster Risk Manag.* **2020**, *10*, 1–22. [CrossRef]
26. Al-Saidi, M.; Hussein, H. The water-energy-food nexus and COVID-19: Towards a systematization of impacts and responses. *Sci. Total Environ.* **2021**, *779*, 146529. [CrossRef] [PubMed]
27. Durodola, O.S.; Nabunya, V.; Kironde, M.S.; Nevo, C.M.; Bwambale, J. COVID-19 and the water–energy–food nexus in Africa: Evidence from Nigeria, Uganda, and Tanzania. *World Water Policy* **2020**, *6*, 176–201. [CrossRef]
28. Nhamo, L.; Ndlela, B. Nexus planning as a pathway towards sustainable environmental and human health post Covid-19. *Environ. Res.* **2021**, *192*, 1103. [CrossRef] [PubMed]
29. Douglas, M. A regional network strategy for reciprocal rural-urban linkages. *Third World Plan. Rev.* **1998**, *20*, 1–34. [CrossRef]

30. Akkoyunlu, S. The Potential of Rural-Urban Linkages for Sustainable Development and Trade. *Int. J. Sustain. Dev. World Policy* **2015**, *4*, 20–40. [CrossRef]
31. Morshed, N.; Yorke, C.; Zhang, Q. Urban Expansion Pattern and Land Use Dynamics in Dhaka, 1989–2014. *Prof. Geogr.* **2017**, *69*, 396–411. [CrossRef]
32. UN-Habitat. The Vancouver Declaration on Human Settlements. In *Report of Habitat: United Nations Conference on Human Settlements*; UN-Habitat: Vancouver, BC, Canada, 1976.
33. United Nations. *Commission on Human Settlements*; Seventeenth Session: Nairobi, Kenya, 1999.
34. United Nations. The Future We Want: Outcome of the Conference. In Proceedings of the Rio +20 United Nations Conference on Sustainable Development, Rio de Janeiro, Brazil, 20–22 June 2012.
35. UN-Habitat. The New Urban Agenda. In Proceedings of the United Nations Conference on Housing and Sustainable Urban Development (Habitat III), Quito, Ecuador, 17–20 October 2016.
36. United Nations Office for Disaster Risk Reduction. Proceedings of the Sendai Framework for Disaster Risk Reduction 2015–2030 3rd UN World Conference on Disaster Risk Reduction, Sendai, Japan, 18 March 2015.
37. Jamshed, A.; Birkmann, J.; Feldmeyer, D.; Rana, I.A. A Conceptual Framework to Understand the Dynamics of Rural-Urban Linkages for Rural Flood Vulnerability. *Sustainability* **2020**, *12*, 2894. [CrossRef]
38. Organisation for Economic Co-operation and Development. Rural-Urban Linkages and Innovation Cities. Available online: https://www.oecd-ilibrary.org/sites/d3aa8741-en/index.html?itemId=/content/component/d3aa8741-en (accessed on 6 November 2021).
39. Department for International Development. Report: DFID's Transport and Urban Infrastructure Investments. Available online: https://icai.independent.gov.uk/html-version/infrastructure/#section-0 (accessed on 6 November 2021).
40. The World Bank. Urban Development. Available online: https://www.worldbank.org/en/topic/urbandevelopment (accessed on 5 June 2021).
41. Takeuchi, K.; Yamada, T. SDGs o gugen-kasuru "chiikijunkankyōsei-ken" no kōsō: Dai 5-ji kankyōkihonkeikaku o yomitoku. *Environ. Manag.* **2018**, *7*, 8–12.
42. Ortiz-Moya, F.; Kataoka, Y.; Saito, O.; Mitra, B.K.; Takeuchi, K. Sustainable transitions towards a resilient and decentralized future: Japan's Circulating and Ecological Sphere (CES). *Sustain. Sci.* **2021**, *16*, 1717. [CrossRef]
43. Takeuchi, K.; Ichikawa, K.; Elmqvist, T. Satoyama landscape as social-ecological system: Historical changes and future perspective. *Curr. Opin Environ. Sustain.* **2016**, *19*, 30–39. [CrossRef]
44. Ramaswami, A.; Boyer, D.; Nagpure, A.S.; Fang, A.; Bogra, S.; Bakshi, B.; Cohen, E.; Rao-Ghorpade, A. An urban systems framework to assess the trans-boundary food-energy-water nexus: Implementation in Delhi, India. *Environ. Res. Lett.* **2017**, *12*, 025008. [CrossRef]
45. Satterthwaite, D.; McGranahan, G.; Tacoli, C. Urbanization and its implications for food and farming. *Philos. Trans. R. Soc. B* **2010**, *365*, 2809–2820. [CrossRef] [PubMed]
46. International Institute for Environment and Development. *Fruitful Change: Rural-Urban Transformation in Vietnam's Mekong Delta*; IIED: London, UK, 2015.
47. Dubbeling, M.; Bucatariu, C.; Santini, G.; Vogt, C.; Eisenbeiss, K. *City Region. Food Systems and Food Waste Management: Linking Urban. and Rural Areas for Sustainable and Resilient Development*; Deutsche Gesellschaft fur Internationale Zusammenarbeit (GIZ) GmbH: Eschborn, Germany, 2016; p. 182.
48. Dubbeling, M.; Santini, G.; Renting, H.; Taguchi, M.; Lançon, L.; Zuluaga, J.; De Paoli, L.; Rodriguez, A.; Andino, V. Assessing and Planning Sustainable City Region Food Systems: Insights from Two Latin American Cities. *Sustainability* **2017**, *9*, 1455. [CrossRef]
49. Food and Agricultural Organization. City Region Food Systems in Antananarivo, Madagascar: A Sustainable Approach to Respond to COVID-19 Outbreak. Available online: http://www.fao.org/in-action/food-for-cities-programme/news/detail/en/c/1272226/ (accessed on 25 September 2021).
50. Food and Agricultural Organization. City Region Food Systems in Medellin, Colombia: A Pathway of Governmental and Territorial Integration to Face the COVID-19 Crisis. Available online: http://www.fao.org/in-action/food-for-cities-programme/news/detail/en/c/1273338/ (accessed on 25 September 2021).
51. Food and Agricultural Organization. City Region Food Systems to Cope with COVID-19 and Other Pandemic Emergencies. 2021. Available online: http://www.fao.org/uploads/pics/City_Region_Food_Systems_to_cope_with_COVID19_and_other_pandemic_emergencies___12.05.2020.pdf (accessed on 25 September 2021).
52. Climate Emergrncy, Urban Opportunity. Available online: http://eprints.lse.ac.uk/103154/1/Rode_climate_emergency_urban_opportunity_published.pdf (accessed on 23 September 2021).
53. Bringault, A.; Eisermann, M.; Lacassagne, S. Cities Heading towards 100% Renewable Energy by Controlling Their Consumption. Available online: https://energy-cities.eu/wp-content/uploads/2018/11/publi_100pourcent_final-web_en.pdf (accessed on 22 September 2021).
54. International Energy Agency. Global Energy Review 2021: Assessing the Effects of Economic Recoveries on Global Energy Demand and CO_2 Emissions in 2021. Available online: https://iea.blob.core.windows.net/assets/d0031107-401d-4a2f-a48b-9eed19457335/GlobalEnergyReview2021.pdf (accessed on 15 September 2021).
55. Flörke, M.; Schneider, C.; McDonald, R.I. Water competition between cities and agriculture driven by climate change and urban growth. *Nat. Sustain.* **2018**, *1*, 51–58. [CrossRef]

56. Bhatia, R.; Cestti, R.; Winpenny, J. Water Conservation and Reallocation: Best Practice Cases in Economic Efficiency and Environmental Quality Water and Sanitation Currents. World Bank-ODI 1995. Available online: https://www.google.com.hk/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&cad=rja&uact=8&ved=2ahUKEwj5yrvow7f0AhV2UGwGHdrBCsYQFnoECAIQAQ&url=https%3A%2F%2Fwww.wsp.org%2Fsites%2Fwsp%2Ffiles%2Fpublications%2F418200731648_waterconservation.pdf&usg=AOvVaw23qlESaAfHZld5QtRSBKSC (accessed on 15 September 2021).
57. Molle, F.; Berkoff, J. Cities vs. agriculture: A review of intersectoral water re-allocation. *Nat. Resour. Forum* **2009**, *33*, 6–18. [CrossRef]
58. Organisation for Economic Co-Operation and Development. A New Era for Water Management in OECD Cities. Available online: https://one.oecd.org/document/ENV/EPOC/WPBWE(2014)5/REV2/en/pdf (accessed on 26 September 2021).
59. World Health Organization. 1 in 3 People globally Do Not Have Access to Safe Drinking Water—UNICEF, WHO. Available online: https://www.who.int/news/item/18-06-2019-1-in-3-people-globally-do-not-have-access-to-safe-drinking-water-unicef-who (accessed on 26 September 2021).
60. Barbier, E.B.; Burgess, J.C. Sustainability and development after COVID-19. *World Dev.* **2020**, *135*, 105082. [CrossRef]
61. Cohen, M.J. Does the COVID-19 outbreak mark the onset of a sustainable consumption transition? *Sustain. Sci. Pract. Policy* **2020**, *16*, 1–3. [CrossRef]
62. Naidoo, R.; Fisher, B. Reset sustainable development goals for a pandemic world. *Nature* **2020**, *583*, 198–201. [CrossRef] [PubMed]
63. O'Callaghan-Gordo, C.; Antó, J.M. COVID-19: The disease of the Anthropocene. *Environ. Res.* **2020**, *187*, 109683. [CrossRef]
64. Ilyas, S.; Srivastava, R.R.; Kim, H. Disinfection technology and strategies for COVID-19 hospital and bio-medical waste management. *Sci. Total Environ.* **2020**, *749*, 141652. [CrossRef] [PubMed]
65. Saadat, S.; Rawtani, D.; Hussain, C.M. Environmental perspective of COVID-19. *Sci. Total Environ.* **2020**, *728*, 138870. [CrossRef]
66. Kalina, M.; Tilley, E. "This is our next problem": Cleaning up from the COVID-19 response. *Waste Manag.* **2020**, *108*, 202–205. [CrossRef] [PubMed]
67. Rahman, M.M.; Bodrud-Doza, M.; Griffiths, M.D.; Mamun, M.A. Biomedical waste amid COVID-19: Perspectives from Bangladesh. *Lancet Glob. Health* **2020**, *8*, E1262. [CrossRef]
68. India today. 46% Increase in Covid Biomedical Waste in April-May, Says Report. Available online: https://www.indiatoday.in/coronavirus-outbreak/story/46-increase-in-covid-biomedical-waste-april-bihar-karnataka-1813935-2021-06-12 (accessed on 22 September 2021).
69. Adamchick, J.; Perez, A.M. Choosing awareness over fear: Risk analysis and freetrade support global food security. *Glob. Food Secur.* **2020**, *26*, 100445. [CrossRef]
70. Bochtis, D.; Benos, L.; Lampridi, M.; Marinoudi, V.; Pearson, S.; Sørensen, C.G. Agricultural workforce crisis in light of the COVID-19 pandemic. *Sustainability* **2020**, *12*, 8212. [CrossRef]
71. Sovacool, B.K.; Furszyfer Del Rio, D.; Griffiths, S. Contextualizing the Covid-19 pan-demic for a carbon-constrained world: Insights for sustainability transitions, energyjustice, and research methodology. *Energy Res. Soc. Sci.* **2020**, *68*, 101701. [CrossRef]
72. Bahmanyar, A.; Estebsari, A.; Ernst, D. The impact of different COVID-19 containment measures on electricity consumption in Europe. *Energy Res. Soc. Sci.* **2020**, *68*, 101683. [CrossRef]
73. Benton, T.G. COVID-19 and disruptions to food systems. *Agric. Hum. Values* **2020**, *37*, 577–578. [CrossRef]
74. Espitia, A.; Rocha, N.; Ruta, M. Covid-19 and Food Protectionism: The Impact of the Pandemic and Export Restrictions on World Food Markets: World bank. Policy Research Work. Paper. 2020, p. 9253. Available online: https://openknowledge.worldbank.org/handle/10986/33800 (accessed on 22 September 2021).
75. Pu, M.; Zhong, Y. Rising concerns over agricultural production as COVID-19spreads: Lessons from China. *Glob. Food Secur.* **2020**, *26*, 100409. [CrossRef] [PubMed]
76. Hospers, L.; Smallcombe, J.W.; Morris, N.B.; Capon, A.; Jay, O. Electric fans: A poten-tial stay-at-home cooling strategy during the COVID-19 pandemic this summer? *Sci. Total Environ.* **2020**, *747*, 141180. [CrossRef] [PubMed]
77. Food and Agricultural Organization. Urban Food Agenda. Available online: https://www.fao.org/urban-food-agenda/en/ (accessed on 3 November 2021).
78. C40 Cities. 2021. Available online: https://www.c40.org/news/cities-committed-race-to-zero/ (accessed on 3 November 2021).
79. The Natural Resources Defense Council (NRDC) and The Council on Energy, Environment and Water (CEEW). Greeting India's Workforce. 2017. Available online: https://www.nrdc.org/sites/default/files/greening-india-workforce.pdf (accessed on 3 November 2021).
80. World Resource Institute. 5 Graphics that Explain Clean Energy Jobs in Rural America. Available online: https://www.wri.org/insights/clean-energy-jobs-rural-communities-us-5-graphics (accessed on 3 November 2021).

Shelter management during pandemics: lessons from cascading risks of cyclones and COVID-19

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Abstract

Purpose – The concept of multi-purpose cyclone shelters has been found effective in saving various lives during past cyclones. The recent cyclone Amphan, which hit the Indian states of Odisha and West Bengal in the middle of pandemic COVID-19 has posed severe issues related to cyclone shelter management in the rural areas. The purpose of this paper is to investigate the case of Odisha in a pandemic and draw some key lessons of cyclone shelter management, which can be useful for future cascading risks in other parts of the country and the region.

Design/methodology/approach – Cyclone shelters are critical infrastructures in the management of cyclones, associated hazards and saving crucial lives. The effective management of shelters during emergencies is dependent on the existing institutional mechanism, local stakeholders and their understanding of the key functions of the emergency shelters. This paper reviews the key challenges through literature, reports and direct interviews of field professionals and practitioners.

Findings – In normal times, cyclone shelters are used as schools and their management lies with the local communities and/or elected bodies. Some of the key emerging issues include: the convincing population at risk for evacuation with proper care, existing emergency shelters being repurposed as COVID-19 facilities, need for hygiene and safety material, special arrangement and segregation of population at higher risk of COVID-19 and large destruction of social infrastructures.

Originality/value – During cascading disasters, adaptive governance becomes important. With the study of cyclones during the pandemic period, the paper draws key decision-making and governance points of cyclone shelter management. This case analysis can be useful to other similar situations during the prolonged pandemic time.

Keywords Early warning system, COVID-19, Cascading risk, Critical infrastructures, Cyclone amphan, Cyclone shelter management, Shelter management

Paper type Case study

1. Introduction

Critical infrastructures (CI) are physical structures, facilities, networks and other assets that provide services that are essential to the social and economic functioning of a community or

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society (United Nations Office for Disaster Risk Reduction, 2017). Further, the CI ensures the safety and well-being of the population (OECD, 2019). From the perspective of disaster risk management, CI are basic lifeline infrastructures that aid in saving lives, connecting to affected communities, supporting response and relief operations and ensuring continuity of normal functioning of life. These include hospitals and health care centers, water supply, power grids, telecommunication, transmission lines, transportation network, control rooms, emergency shelters, etc. These CI functions as an interrelated system of systems and interact with each other for supporting the normal functioning of key services. Due to this, the impact on one often triggers a cascading effect on others during disasters (Private Sector Alliance for Disaster Resilient Societies [ARISE], UNDRR, 2017).

Thus, the resilience of CI is a defining factor for a hazard to become a disaster. The Sendai Framework for Disaster Risk Reduction (2015–2030) lays down seven global targets. Target D calls for substantial reduction of disaster damage to CI and disruption of basic services through, amidst others, developing their resilience by 2030 (United Nations Office for Disaster Risk Reduction, 2015). Besides, the resilience of CI is crucial toward achieving other global targets of the Sendai Framework including a substantial reduction in disaster mortality, number of disasters affected people and direct disaster economic losses. Mohanty *et al.* (2020) did an extensive review on CI and its role in disaster risk reduction. OECD (2019) defined CI as systems, assets, facilities and networks that provide essential services for the functioning of the economy and the safety and well-being of the population.

Hazards such as cyclones and floods often trigger large-scale evacuations in the coastal and at-risk communities. During such times, the emergency shelters offer safe spaces to the evacuated population till it is safe for them to return to their dwellings. Thus, particularly for coastal communities, emergency shelters are considered as CI as they help in reducing potential life loss and injuries. The management of emergency shelters during normalcy and disasters is full of diverse challenges and requires institutional and community level preparedness and awareness for their effective use. Some of these challenges include space management, management of basic services at the shelter, management of relief aids, etc.

Along with a huge life loss, the current pandemic of COVID-19 has caused large-scale disruption in the socio-economic functioning of the global society. Different parts of the world such as the Philippines (Typhoon Vongfong); India and Bangladesh (Super cyclone Amphan); the Solomon Islands, Vanuatu, Fiji and Tonga (Cyclone Harold) have braved cyclones or typhoons or hurricanes during the current pandemic (UNOCHA, 2020). This has aggravated the challenges for the respective authorities and stakeholders in the management and functioning of the emergency shelters. These include, among others, increased fear among the evacuated population of contracting the COVID-19 infection, ensuring physical restrictions measures during evacuations and at shelters, exposure to crowded conditions movement restrictions of external aid-workers, deployment of teams for needs assessment (UNOCHA, 2020), increased use of personal protection equipment (PPE) and hygiene supplies and practices and the involved additional cost (CDC, 2020a, 2020b).

This paper explores various such challenges faced in the functioning and management of shelters during complex risks of cyclones and the pandemic. A case of the Indian coastal state of Odisha is studied for understanding the management of emergency shelters with a special focus on their management during the complex risks of super cyclone Amphan and the COVID-19. Further, the paper seeks to draw key lessons and good practices undertaken by local authorities and local communities for the same.

2. Methods

The paper uses the case study approach to study shelter management during cyclones and floods in general and pandemics in particular. This has been done by studying the Indian coastal state of Odisha, which is frequented by cyclones and floods each year and has also recently braved the super cyclone Amphan during the current pandemics. This provides a good case for exploring the challenges in the management of shelters from the perspective of cascading and complex risks. The paper makes use of both primary and secondary data for undertaking the study. The secondary data is collected through the desk-based review of relevant resources. The secondary data such as government reports, studies, guidelines, memorandum have been collected through consultation with the relevant officers of the Odisha State Disaster Management Authorities. The primary data is collected through interviews of key personnel at the state level and the field level. The interviews were guided by a detailed open-ended qualitative questionnaire that covered various aspects of shelter management during normalcy, cyclones/floods and complex risk of cyclones and COVID-19. Some of the key issues targeted through the questionnaire include accessibility and suitability of location, capacity and space management particularly during COVID-19, key facilities available in the shelter and impact of COVID-19 on them, the functioning of shelters during normalcy and disasters, the mechanism for operation and maintenance of shelters, social acceptance of shelters during cyclones/floods and COVID-19, etc.

The key limitation of the study is that at the time of writing this paper, the state of Odisha was braving the floods due to which the interviews of all the key officials and stakeholders could not be scheduled. However, the study includes the interview of one community mobilizer from one of the Cyclone Amphan affected districts and one State personnel who looks after the management of shelters at the state level.

3. Literature review

Resilience is defined as "the ability of a system, community or society exposed to hazards to resist, absorb, accommodate, adapt to, transform and recover from the effects of a hazard in a timely and efficient manner, including through the preservation and restoration of its essential basic structures and functions through risk management" (United Nations Office for Disaster Risk Reduction, 2017). The resilience of CI is a defining factor in mitigating the adverse impacts of a potential hazard. Resilience, in the context of CI, is defined as the ability of a facility or asset to anticipate, resist, absorb, respond to, adapt to and recover from a disturbance. Out of the various approaches of vulnerability reduction, the engineering school of thought emphasizes the presence of safe structures and built environments in hazard-prone areas along with appropriate construction practices and materials to increase their resistance (McEntire *et al.*, 2010).

Findings based on a study in South-Western Bangladesh highlight that the infrastructure and structural protection requirements include multi-purpose cyclone shelters (MPCS) along with permanent embankments and suggested dependence of local communities on them because of their critical importance in reducing disaster risk and saving lives (Wedawatta *et al.*, 2016). The concept of having in place structurally engineered infrastructures as cyclone shelters was undertaken in Bangladesh during the 1960s and in India post a devastating cyclone in Andhra Pradesh in 1977 (Dash and Walia, 2020). Afterward, the concept of establishing MPCS was introduced to ensure that regular maintenance of the structures even during non-disaster times. This also helps in ensuring efficient utilization of the MPCS by local authorities and local communities.

3.1 Key challenges faced in shelter management during COVID-19

One of the key guiding principles for emergency shelters includes their being disaster-resilient so that the evacuated population is not further inflicted with any life loss or injuries due to other potential risks in the shelters (NDMA, 2019). This principle is significantly relevant in the context of cascading and complex risks. The recent occurrences of various cyclones amid the pandemic of COVID-19 are among such complex risks that have aggravated the challenges for the affected population, local authorities, response agencies and other key stakeholders. While the emergency shelters do provide a haven to the evacuated populations, their potential crowded settings provide a high-risk ground for transmission of COVID-19. This has posed new challenges in managing and ensuring effective management and functioning of emergency shelters in various aspects. Some of these challenges include convincing the population-at-risk to evacuate to shelters amid fear of COVID-19 infection; physical distancing, respiratory etiquettes and hygiene practices at the emergency shelters (CDC, 2020a); efficient management of available physical and financial resources; reduced availability and access to external aid due to COVID restrictions.

Fear and uncertainty about the COVID-19 in the local population made it challenging for the local authorities, community mobilizers, response agencies and volunteers to convince the population-at-risk for evacuation. There have been cases of some families fleeing the emergency shelters in West Bengal during cyclone Amphan amidst fear of getting COVID-19 infected (Ober, 2020). There are also recorded incidents of some of the affected areas refusing relief aid due to fear of contracting infections (Ober, 2020).

The COVID-19 and its essential requirement of physical distancing reduced the effective capacity of the existing emergency shelters and fewer evacuated persons could be accommodated in a given shelter. The Centers for Disease Control and Prevention (CDC) prescribed the evacuated population to maintain a six feet distance from other evacuees outside one's household (CDC, 2020b). To ensure that the used emergency shelters are COVID-proofed and duly comply with required norms of physical distancing, during the cyclone Amphan, the emergency shelters could accommodate only 0.2 million persons instead of their usual capacity of 0.5 million persons (Ober, 2020). Similarly, in Bangladesh, around three times the usual numbers of emergency shelters and other infrastructures were used during cyclone Amphan (Ober, 2020).

The cases of Indian coastal states of West Bengal and Odisha illustrate another kind of challenge for the local authorities during the management of dual risks of COVID-19 and cyclone Amphan. Much before the states were struck by the cyclone, various existing emergency shelters were repurposed into different facilities for the management of COVID-19 (Dasgupta, 2020). These include quarantine centers, temporary medical centers (TMC), centers for the migrant workers returning from other states. Due to this, on the receipt of the warning for the cyclone, the local authorities and stakeholders had to promptly identify new and safe structures such as schools, colleges, community halls and government buildings, which can be repurposed as emergency shelters. While some of these buildings were already vacant due to COVID-19 imposed lockdown.

The COVID-19 has necessitated the local authorities to ensure the provision of additional supplies and services such as clean water for regular handwashing, soaps, disinfection gels, sanitizers, masks and PPE for first-line responders. Not only is this an additional pressure on the budget of local authorities but also this can be challenging at times considering that often the natural hazards such as cyclones and floods disrupt the water supplies, drainage and sanitation and power infrastructures; thus, indirectly impacting the COVID-19 control measures (T.V.Pandya, 2020).

The prompt response and relief actions by non-governmental agencies, for the management of cyclones amid the restrictions of COVID-19, are also dependent on the timely ease of restrictions by the local authorities. The cases of cyclone Harold, cyclone Amphan and typhoon Ambo illustrate how the high-risk perceptions and awareness of local authorities on cyclones, floods and the high risk they pose to life and health of the population can trigger the local authorities to appropriately relax the COVID-19 restrictions for facilitating early actions by external stakeholders (Lux, 2020). Besides, in some cases, various COVID-19 restrictions on travel and movement limited the assistance, the headquarters of non government organizations (NGOs) and other external stakeholders can provide to their local partners in the affected areas (Lux, 2020). This highlights a crucial aspect of the local actors being adequately trained and equipped to perform the required roles even with limited support from outside.

In a recent report from Japan, Das *et al.* (2020) explored the key challenges in evacuation centers in post-flood situation during COVID-19. The report focused on evacuation behavior, the community's reluctance to go to evacuation centers for the fear of contamination, space issues in evacuation centers (due to 40% occupancy guideline from the government), specific care in the centers to avoid contamination and volunteer management. The report emphasized on adaptive governance approach and urged for a strong link of local governments, civil societies and communities.

4. Management of shelters during complex risks of COVID-19 and cyclone Amphan: a case study of Odisha

The state of Odisha is located on the eastern coast of India and among other hazards, it is frequented by tropical cyclones and floods almost every year. It has a vast coastline of 480 km, which makes it highly vulnerable to tropical cyclones and tidal surges (Figure 1). The state has 11 major rivers; the largest river system of Mahanadi along with its tributaries and distributaries poses a severe threat of floods in the state. The increased frequency and severity of these hazards are attributed to climate change. Over the past two decades, tremendous efforts have been made by the Government of Odisha in institutionalizing disaster risk management. The concerted efforts by various stakeholders have led to a substantial reduction in life loss during recurring cyclones, floods and other hazards. One of the steps in this direction is having in place safe multi-purpose cyclone and flood shelters supported by a robust mechanism of their management. Because of its hazard-prone profile and an effective shelter management system in place, the current study selected the State of Odisha as a case study to better under the management of shelter, especially during the current times when the risk of cascading or complex emergencies are on the rise.

4.1 COVID-19 situation in Odisha

The first case of COVID-19 was reported in the State on March 16, 2020. The State was among the first ones to announce the lockdown. It was the first Indian State to set up a dedicated hospital for COVID-19 patients (NDMA and CDRI, 2020). As per the Press Release, Government of Odisha, up to midnight of August 19 2020, the number of positive cases is 70,020 with 380 deaths. So far, 48,576 persons have already recovered/discharged. Besides, Odisha is one of the major sources of migrants who travel to other states for work. Due to the current pandemic and resultant national lockdown, the return of a large number of migrant workers posed additional challenges for the management of the COVID-19 situation in the state.

Figure 1.
Wind and cyclone-prone zones of Odisha

Source: Odisha State Disaster Management Authority (OSDMA)

4.2 Impact of cyclone Amphan in Odisha

The Super Cyclonic Storm Amphan crossed West Bengal as a Very Severe Cyclonic Storm with a speed of 155 kilometers per hour (kmph)–165 kmph gusting to 185 kmph across Sundarbans. The damages in the State of Odisha were mainly caused by gusting wind and heavy rainfall. It affected around 4.53 million people from 9,838 villages of 97 blocks and 272 wards of 22 Urban Local Bodies in 10 districts of the State. A total of 200,346 people were evacuated from vulnerable areas of Odisha to 4,314 shelters (Government of Odisha, 2020).

Besides causing varying levels of damage to *kutcha* houses, *pucca* houses, huts and cowsheds, Amphan and associated heavy rainfall have led to the death of 17 large milch animals, 7 small milch animals, 14 draught animals and 4,685 poultry birds. Further, it has affected 1,903 livestock and 18,875 poultry birds. Over 3,000 hectares of agriculture, horticulture and perennial crops have sustained a crop loss to the extent of 33% and above (Das *et al.*, 2020). In addition to these, Amphan has caused damage to around 151 kilometers (kms) of rural roads, over 200 kms of public works department (PWD) roads, 17 kms of urban roads, 3 kms of drainage, 73 kms of embankments, 71 PWD buildings, 646 Anganwadi Centers, 1,552 primary school buildings, 298 Gram Panchayat Buildings/ Community Centers. Due to damage to their equipment and raw materials, 5,400 traditional craftsmen and artisans have lost their livelihood (Das *et al.*, 2020). In the Final Memorandum of Super Cyclonic Storm Amphan, the Government of Odisha notes that Amphan has led to damage and loss of public properties amounting to INR 2,209.61m and an amount of 152.72m was spent on immediate relief needs.

4.3 Cyclone shelters in coastal India

In India, various lessons are learned from the Odisha Super Cyclone of 1999, which struck the state with over 300 kmph of wind speed. It was recognized that precious lives were lost due to the lack of safe emergency shelters. Further, the importance of cyclone shelters as critical life-saving infrastructure was exemplified by 23 cyclone shelters in some of the coastal districts of the State, which reportedly provided refuge to and saved 42,000 lives during the Super Cyclone of 1999. These were constructed by the Indian Red Cross Society (Odisha State Branch). This was an eye-opener for the government and has thereafter positioned cyclone shelters as CI for safeguarding lives (Odisha State Disaster Management Authority). The critical role emergency shelters (cyclone and flood) have played during disasters in Odisha is further underscored by studying the cases of various disasters the state braved post-Super Cyclone 1999 too. Table 1 shows a comparative data set of life loss and the number of persons evacuated along with the number of shelters used during major cyclones faced by the state.

In the aftermath of the Super Cyclone of 1999, the Indian coastal state of Odisha has recognized the need for disaster resilient shelter buildings as part of its long-term disaster risk reduction initiatives. This led to the construction of around 135 MPCS by the Government of Odisha using Chief Minister's Relief Fund, Prime Minister's Relief Fund and support from World Bank. Subsequently, the National Cyclone Risk Mitigation Project (NCRMP) was initiated in 13 prone states and union territories (UT) of India in a phase-wise manner. NCRMP was envisaged to undertake suitable structural and non-structural measures to mitigate the effects of cyclones in the coastal states and UTs of India. The key components of NCRMP included construction and sustainable maintenance of MPCSs, improved access and evacuation to shelters, construction of coastal embankments; strengthening of early warning and communication systems and enhancing capacity and capability of local communities.

Another project having the component of the construction of MPCS is the integrated coastal zone management project (ICZMP). The key objective of ICZM is building national capacity for the implementation of a comprehensive coastal management approach in the country. It is being piloted in the states of Gujarat, Odisha and West Bengal.

4.4 Cyclone shelter management system in Odisha

In Odisha, there a total of 879 multi-purpose cyclone and flood shelters. Out of these, 65 have been constructed by the Indian Red Cross Society and the remaining by the Government of Odisha under various schemes and programs including NCRMP, NCRMP (Additional Financing), ICZMP, through funding from Prime Minister and Chief Minister's Relief Fund, World Bank, Container Corporation of India, etc. (OSDMA, 2014a, 2014b). Most of these

Table 1. Number of deaths and persons evacuated during major cyclones in Odisha

Cyclone	Deaths	Persons evacuated	Shelters used
Super cyclone, 1999	10,000	42,000	23
Very severe cyclonic storm, Phailin, 2013	27	9,83,642 (cyclones), 1,71,083 (floods)	4,197
Very severe cyclonic storm, Hudhud, 2014	3	2,55,043	2,143
Very severe cyclonic storm, Titli, 2018	71	3,60,132	1,612
Very severe cyclonic storm, Bulbul, 2019	0	11,458	100
Extremely severe cyclonic storm, Fani, 2019	64	Around 15,500,00	9,177
Super cyclonic storm, Amphan, 2020	0	2,00,346	4,314

Source: Memorandum, Government of Odisha shelters are situated inside existing school premises or adjacent to schools. Five of the MPCS constructed under NCRMP are shelters-cum-storage. The capacity of these shelters varies from 1,000–2,000 persons. Shelters have provision for separate hall and toilets for men and women along with one extra room for sick/labor room and one store-room. The shelters are provided with basic amenities such as water, light and sanitation. Drinking water is provided through a submersible pump. Each shelter has a power backup through a 5 KVA generator set.

A community-based management and maintenance system is in place for the shelters in the state whereby Cyclone/Flood Shelter Management and Maintenance Committees (CSMMC/FSMMC) have been formulated and imparted managerial training. CSMMCs and FSMMCs are registered as a society under the Societies Registration Act, 1860, and are governed by by-laws of the respective societies. The committees are constituted through a *Pali Sabha* (special community meeting) convened by the local Block Development Officer/ *Sarpanch* (village head) of the concerned block/*Gram Panchayat* (village council). Each committee comprises around 21–25 members. *Sarpanchs* of concerned *Gram Panchayat* and Executive Officers in the urban local body are ex-officio Presidents of the committees. The composition of committees reflects a mix of local government officials, political members from concerned ward and hamlets and representatives from different sections of the community including representatives of women, persons with disabilities, scheduled caste/ tribe, self-help group, local NGO/village club, etc. Such a composition is effective for nurturing the culture of community ownership in the usage and management of the shelters. The local community is responsible for the day-to-day maintenance of the shelter and is supported and cooperated by the committee.

Another special feature of cyclone shelter management in Odisha is that the shelters are being used as multi-purpose shelters. During normal times, these are used as schools and this is supported by the provision of an inbuilt backboard in the hall and the respective Headmaster is responsible for cleaning and maintaining the shelter. Besides when not in use, shelters could be used for government programs, social, cultural and economic purposes on payment of user fees. A joint account is used for keeping the collected fees and the same could be spent for repair, maintenance and disaster preparedness activities. However, no one is allowed to use the shelter or its campus permanently. As the primary purpose of these infrastructures is that of cyclone and flood shelter, so when used for other purposes, the laid down norm is to vacate the building and keep it ready for use as shelter on receipt of early warning. In addition, the shelter management system has a laid down mechanism for dispute resolution whereby any dispute regarding management or use of shelters is brought to the notice of the local Block Development Officer, respective District Collector and OSDMA.

5. Shelter management during cyclone Amphan and COVID-19: key emerging issues

The state of Odisha has faced cascading or complex risks in the past when in 1999 it has experienced 2 cyclones within 11 days. In 2014, the state braved back-to-back cyclone Phailin and two rounds of floods, which has increased the duration of the disaster phase. This also necessitated an evacuation of around 0.98 million persons from 14 districts due to cyclones and a subsequent evacuation of around 0.17 million persons from 3 districts that were severely affected by floods. During Phailin, the most common problems reported by evacuees to shelters include concerns of insufficient space, shortage of food and water and the absence of toilet facilities (OSDMA, 2014a, 2014b).

The challenges posed by the current pandemic of COVID-19 in Odisha were aggravated for the government machinery and other stakeholders when the warning for Super Cyclonic Storm Amphan was received. On receipt of warning for Amphan, the key stakeholders were asked to ensure preparedness measures for prompt response and relief and to immediately check and keep all multi-purpose cyclone and flood shelters ready for use. At the shelter level, meetings of respective CSMMC/FSMMC were organized to ensure all measures are timely taken and required facilities are in place in the shelter. The actions included undertaking prompt repair work if needed; testing the water supply system, generators, inflatable tower lights, mechanical cutters and other equipment available in the shelter. Fuel arrangements were also made for generators and other equipment (SRC, 2020). Two teachers were identified as in-charge of each of multi-purpose cyclone and flood shelters and other alternate shelters and they were to coordinate and report on the management of shelters. Cooked food through free kitchens was provided to the evacuees.

5.1 Convincing population-at-risk for evacuation amidst fears of transmission of COVID-19 infection

To begin with, one of the key challenges posed by COVID-19 was that in some cases people were hesitant in leaving houses and taking refuge in shelters. Before the receipt of the warning for cyclone Amphan, the communities were being made aware of the impacts of COVID-19 and were advised by the local authorities to stay inside and venture out only for necessary work. However, immediately after the cyclone warning, the population-at-risk were asked to prepare for evacuation and leave for safe shelters. This drastic shift in advisories by the local authorities from stay-in orders to evacuation orders made it challenging for the local population to perceive the complex risk. This required sensitization of the people on the necessity of evacuation from vulnerable locations and how the cyclone could be more be life-threatening than the COVID-19 infection. The challenge was particularly higher for evacuation in COVID-19 red zones. During the dissemination of early warning and evacuation operations, efforts were made by community mobilizers and other volunteers to sensitize the affected population on aspects of physical distancing, and were asked to use masks/clean cloth to cover their mouth and noses during evacuation and their stay at the shelter.

5.2 Existing emergency shelters being repurposed as COVID-19 facilities

The first COVID-19 case was reported in Odisha on March 16, 2020. When the warning for Amphan was received on May 15 2020, the number of positive cases of COVID-19 in the State was 672 with 3 deaths (IPR, 2020). By this time, some shelters were already being used as COVID-19 TMC in the state to quarantine people coming from different states/countries. This along with the need for following physical distancing protocols required identifying additional structurally safe infrastructure that could be used as emergency shelters for evacuees (SRC, 2020). The vacated shelters, which were earlier used as TMCs were thoroughly sanitized to prevent the spread of infection and also to gain the confidence of incoming evacuees.

5.3 Need for hygiene and safety material

It was found that the pandemic-induced requirement of physical distancing was not practical to be followed by the response and relief forces who were undertaking evacuation and search and rescue operations, clearance of emergency routes, etc. Besides, it was challenging for the response forces to undertake these operations while wearing the full PPE suits as it was impacting the efficiency and speed of the operations to be undertaken. The high prevailing temperature made it further difficult. Thus, the response forces were advised to wear masks and follow adequate COVID-19 protocols without compromising the efficacy of response and relief operations.

At the shelter level, the pandemic mandated additional provision of PPE and extra supplies such as masks, soap and an adequate supply of water. However, at the local level, it was not possible to promptly arrange and distribute individual PPE kits/masks/face shields to all the evacuees. Thus, the community mobilizers ensure that evacuees are duly sensitized for carrying their masks, cloth pieces and practice personal hygiene and physical distancing to the best extent possible during their stay at the shelters. The respective shelter committees and in-charges ensure an adequate supply of clean water for handwashing and maintaining personal hygiene through the provision of water tankers, wherever required. The shelter committees and in-charges were also advised to make use of liquid soaps instead of traditional soap bars in the shelters to mitigate the spread of any infection among the evacuees in the shelters.

5.4 Special arrangement and segregation of population at higher risk of COVID-19

Various special arrangements were undertaken at the shelter level to mitigate the potential spread of COVID-19 infections among the evacuees, shelter managers and volunteers. Provision of cooked meals with the help of local self-help groups was undertaken. Aspects of physical distancing were practiced for the dining arrangements of the evacuees. Considering the higher vulnerability of elderly persons and pregnant women to COVID-19, the authorities recommended the shelter managers and in-charges to separate them from other evacuees and refrain them from mingling with younger people as far as possible. Moreover, pregnant women with deliveries due in the next 15 days were directly taken to hospitals.

5.5 Large destruction of social infrastructure

As per the Memorandum, no human life loss has been reported during cyclone Amphan (Special Relief Commissioner, Government of Odisha, 2020). However, large destruction and damage to public properties have been experienced due to cyclonic winds and heavy rainfall. In terms of finances, maximum losses have been incurred by Panchayati Raj and Drinking Water Department due to damage to Anganwadi Centers, primary school buildings, buildings and community centers, roads and drinking water supply systems (Special Relief Commissioner, Government of Odisha, 2020).

Large damage to social infrastructure such as schools and community centers in rural areas is a point of concern as often these structures are used by local communities for taking refuge during disasters. Besides, the current COVID pandemic has limited the capacity of existing shelters due to various physical distancing norms. This has increased the need of identifying alternate safe shelters and social infrastructure such as schools, colleges and community centers are expected to play this critical role. Thus, the physical and structural resilience of the existing and identified emergency shelters is of paramount importance while assessing and building the capacity of any community.

6. Discussions

Key learning for shelter management during cascading risk can be summarized as follows:

6.1 Understanding multiple and cascading risks for building disaster-resilient shelters

The Target D of Sendai Framework for Disaster Risk Reduction (2015–2030) calls for a substantial reduction of disaster damage to CI and disruption of basic services through, among others, developing their resilience by 2030 (United Nations Office for Disaster Risk Reduction, 2015). Besides, the resilience of CI is crucial toward achieving other global targets of the Sendai Framework including a substantial reduction in disaster mortality, the number of disaster-affected people and direct disaster economic losses. Complete assessment of CI systems/assets covering all aspects from threat to outcome in a disaster is crucial for measuring the resilience of CI (Petit *et al.*, 2011). Thus, the construction and management of shelters should be duly based on an informed understanding of disaster and climate risks. Cyclones are associated with events such as heavy rainfall, strong winds and tidal surge. The identification of the shelter location, design, construction material and practices should be cognizant of all the potential risks. Besides the associated hazards, the risk assessment should be inclusive of all potential hazards including the local ones.

Such a practice was followed by Odisha in the aftermath of Super Cyclone of 1999 whereby a technical need-assessment study was conducted by IIT (Indian Institute of Technology) Kharagpur for identification of 512 locations vulnerable to cyclone and storm surge within 10 km zone of coastline in 6 coastal districts of the state. Accordingly, designs and sites of the shelters were finalized along with the provision of an approach road to each of them. Cyclone shelters in Odisha have been constructed to structurally withstand high wind speed and moderate earthquakes. Constructed above high flood levels with raised platforms and stilted floors, the shelters on the first floor do not get affected by very heavy floods (OSDMA, 2014a, 2014b). There is also a provision of the lightning arrestor system in some shelters. Due consideration of multi-hazard risks for the construction of safe shelters can go a long way in mitigating impacts and damages possible due to cascading and complex risks. However, considering the new and emerging risks such as that of COVID-19, which have compounded the challenges for shelter management, the disaster-resilient features of emergency shelters should consider critical aspects of natural ventilation. Natural ventilation of closed and crowded settings is considered to be very effective in ensuring fresh air circulation and potentially eradicating the COVID-19 virus (PAHO, 2020).

6.2 Undertaking assessment of resources for the management of cascading risks

For the management of future complex risks, it will be very useful to re-assess the effective capacities of existing resources available in the shelter. These include calculating the effective space/area available in the shelter for sleeping and dining purposes with due considerations for aspects of physical distancing. For example, to re-assess the effective sleeping area in a shelter, the suggested standards can be laid down for adequate distance between two beddings along with mechanisms such as ensuring alternate head-to-toe arrangements for persons belonging to different families (PAHO, 2020). Similarly, the calculation of effective space should also consider the space requirement of wheelchair-bound persons. Other key points of considerations include estimating an adequate amount of safe and clean water, necessary hygiene material, dustbins, etc. that should be made available so that all persons in the shelter can practice the recommended norms of hand-washing, sanitizing, safe disposal of wastes, etc. It includes re-assing the required quantity of soaps, disinfectants and human resources to ensure safe management of the shelters. To undertake such re-assessment, minimum standards for different resources/practices can be laid down with the help of health and subject-experts. This can aid in undertaking strategic decisions for using a particular shelter by having a better understanding of its maximum and effective capacities to cater to different risks.

6.3 Modifying the existing layouts and practices in the emergency shelters

Dedicated areas in the shelter for specific purposes such as sleeping, dining and queues should be modified in due consideration of norms of physical distancing. These can be marked in chalk or tapes (CDC, 2020a, 2020b) or paint along with appropriate signages duly displayed in local languages. At shelters with fewer capacities, safe makeshift arrangements can also be undertaken in the adjacent space for sanitizing the evacuees, disinfecting their belongings, area for handwash, dining area, area for segregating/isolating evacuees at higher risk of infection.

Members belonging to the same family can be grouped and made to stay together with limited or no physical interaction with others in the shelter. To avoid transmission of infection in closed spaces, practices of cooking in shelters can also be replaced by either distribution of pre-packaged meals or pre-cooked meals for the evacuees. Foods and beverages can be served in disposable dishwares to avoid sharing of common surfaces and things (CDC, 2020a, 2020b). Besides these, pathways/entries to the shelter can be restricted to limit crowding or allowing restricted entry. Other means to limit crowding and ensuring physical distancing in shelters in establishing separate entry-exit points or one-way movement or putting footprints at a suitable distance on the floor. Staggered timing/schedule for dining, drinking water, bathing, washing or availing of other services at the shelter can also be used to restrict the interactions and mingling of persons in the shelter.

6.4 Repurposing existing resources and spaces as shelters

The need for identification of alternate buildings as shelters can be met by repurposing vacant, underused or private buildings such as schools, colleges, hotels and community centers (AON, 2020). Temporary building features such as partitions can be used to make respective facilities serve the required purpose. However, these alternate buildings should be duly identified after undertaking assessment measures such as rapid visual screening to examine the probable hazards and risks in the buildings. As these assessments are to be taken by trained and skilled personnel, it is recommended that these buildings are pre-identified during times of normalcy as preparedness and capacity-building measures by the local authorities.

6.5 Enhancing the accessibility of shelters

Accessibility of the shelters is of paramount importance in assessing their effectiveness during disasters. Cyclones and associated hazards often disrupt, flood, obstruct the access roads to shelters. Thus, the aspect of safe and easy access to the shelter by the at-risk community is pertinent. The case of Odisha shows both the ease and safe access to shelters have been duly considered during the assessment study by IIT Kharagpur. The basic principle followed by the study was to ensure that each individual can access the safe shelter without having to run for more than 2.25 km and without crossing any natural barrier during any disaster. A grid analysis of 10 square km (3.15 km X 3.15 km) for identification of the location of shelters (OSDMA, 2012). The sites chosen are wide enough so that access road could be developed.

Another aspect of accessibility is that the built environment has traditionally been designed with healthy people in mind. Emergency shelters as a part of the built environment should be specifically designed to ensure easy access and usage by all with a special focus on the needs of persons with disabilities, old age, etc. Faruk *et al.* (2018). The shelters in Odisha have varied features of universal design to make them accessible and friendly in use by persons with disabilities. These include a unisex multiuse accessible toilet, contrast color band steps and path to make them visible during dimmed light, handrails, ramps, tactile tiles on the pathway from the entrance gate and in corridors.

6.6 Understanding local community and context

Often it is experienced that the community at-risk is a bit reluctant in leaving their belonging and going to safe shelter. Though the interaction with one of the community organizers of Odisha suggests that because of extensive awareness programs and the recurring nature of floods and cyclones, the community now readily takes refuge in safe shelters during disasters. Still, a few cases are experienced where they tend to delay leaving the dwelling till the very last moment or till enforced with help of the Police Department. In the backdrop of this, it is valuable to understand the local needs and issues to make the shelter more and readily accepted by the community at-risk. The case of the multi-purpose cyclone and flood shelters of Odisha provides a useful insight in this regard. The ground floor of the shelters can be used for sheltering livestock during disasters. Thus, it tends to address the concerns of those households whose livelihood are dependent on their livestock and are concerned about leaving them alone during disasters.

It has been experienced that the management and maintenance of safe shelters are best done at the lowest level by the local community and authority. Such a principle of decentralization is crucial from multiple perspectives. First, it brings a sense of ownership in the local community, which enhances the usage and acceptance of these shelters to the fullest. Second, the local community and authorities are better placed for the close and day-to-day supervision and maintenance of the shelters. Third, during disasters, it is not humanly and administratively possible and efficient for a centralized authority to manage the local needs and requirements of a particular shelter.

6.7 Local interventions

The review of cyclone shelters of Bangladesh highlights that in the absence of a bottom-up approach, which includes key local stakeholders for establishment and management of cyclone shelters, various crucial issues such as those concerning special needs of gender, disabled population, children, signages, storage facilities, space management to suit local contexts are often left out (Faruk *et al.*, 2018). Thus, participative identification of potential risks including health risks in and around the shelter by the local community and stakeholders should be promoted. These may include non-structural hazards, issue of snake bites, reptiles, water stagnation, vector borne-diseases, improper disposal of waste, etc. Participative mechanism of identifying local issues can bring forth a collective and more acceptable solution to the problem identified. The capacity building of the local communities, community-based organizations, volunteers, etc. is very crucial so that they can sustain their efforts toward the management of shelters at the local level even with limited external assistance, which becomes challenging in times such as pandemics and resulting restrictions in travel and mobility.

Considering the cascading risks posed by COVID-19, during the warning period of cyclone Amphan, the local government in Odisha with the help of Block Development Officers and other field officials pre-identified, inspected, verified alternate buildings and declared them as safe shelters for cyclone Amphan. These included schools, colleges and some private buildings. However, such prompt action by local authorities during the response phase can be undertaken when during the pre-disaster phase, the local stakeholders have been made aware of potential local risks and are duly trained to perform their respective roles, which in this case includes rapid survey/assessment of alternate structures to declare them safe for use during disasters. Thus, this underscores a critical need for building the capacity of the key local stakeholders at regular intervals. Apart from its safe location, all-weather access and connectivity to safe shelters is one of the defining factors in making the shelters effective during disasters. Lack of such a resilient road network and transport infrastructure has been found as a major impediment for most vulnerable and remote coastal and riverine communities to reach safe shelters in Bangladesh (Alam and Collins, 2010). This can also cause potential delays in the dissemination of early warning to these communities by local authorities. Thus, a crucial role of local government lies in effective monitoring and regular maintenance of CI connecting the shelters with the communities.

There are provisions for solar energy, rainwater harvesting, etc. in some of the cyclone shelters in Bangladesh (Faruk *et al.*, 2018). These provisions can be useful in overcoming the issues faced in some of the shelters concerning the shortage of water especially during COVID-19, which has necessitated frequent hand washing and sanitizing to curb the spread of the infection. Joint efforts by the local community and authority in this direction can go a long way in overcoming some of the potential issues faced in the shelters during disasters.

6.8 Technological interventions

The case of Odisha brings forth the use of digital platforms for the registration of migrants for TMC. Similar database management systems could also be explored for registering the evacuees at shelters. Considering the challenges posed by the current pandemic, such a system can also be integrated with COVID-19 risk assessment and risk communication applications such as Aarogya Setu, the COVID-19 risk assessment tool and others. These tools could be used during the early warning dissemination phase along with field surveys by community mobilizers (in areas with limited digital literacy or resources). This could be useful in segregating persons at high-risk and special measures could be then undertaken for them. This may seem a challenging task considering the lakhs of evacuees but possibly by building the capacity of local community and disaster management teams of each shelter, such efforts could be undertaken at the shelter level. Besides, map-based tools could be used for pre-identifying and mapping the locations and capacities of alternate safe infrastructure that could be used as shelters during complex emergencies.

However, it must be acknowledged that cyclones and floods often lead to power outages, so dependency on any technological intervention should be mindful of these limitations. This requires that such technological interventions should be supported by putting in place robust mechanisms for providing continuous power and internet supply at CI such as safe shelters. Alternately, these tools could be used during the preparedness and early warning phases for planning and taking strategic decisions.

7. Conclusion

On the journey of the Sendai Framework of Disaster Risk Reduction and Agenda 2030, it is noteworthy that emergency shelters have been very effective in providing refuge to at-risk communities, and thus, reducing life loss to a great extent. It should be acknowledged that this was possible because concerted efforts were also made in direction of strengthening the early warning mechanism, laying down evacuation protocols putting in place robust institutional mechanism including the raising of trained and well-equipped response forces, enhanced engagement of local community and organizations, etc. (OSDMA, 2014a, 2014b). Without these measures in place, timely, safe and inclusive evacuation of exposed masses to safe shelter seems challenging. Bosher *et al.* (2007) (as cited in McEntire *et al.* (2010)) highlight that while engineered protective measures do offer a safer built environment in hazard-prone areas, often the vulnerable people and communities lack the resources and ability to build such safe structures on their own. In the backdrop of this, the presence of emergency shelters at the community level is of immense importance in providing refuge to vulnerable communities during any disaster. This is all the more relevant to developing countries where the individual capacities of vulnerable households are limited. This dependence of the poor and vulnerable population on community-level safe infrastructure is underscored by Wedawatta *et al.* (2016). However, as the population is ever-increasing and considering the challenges of complex emergencies, there is a need for a holistic approach of vulnerability reduction, which is not merely dependent on engineered structures but also takes into consideration aspects of socio-economic, demographic and exposure of a community and aims to address the systemic risks and root causes of vulnerability. Moreover, the need for an all-of-society approach based on consideration of multi-hazards cannot be overemphasized for a resilient and sustainable planet, particularly during the current times.

The complex risk of COVID-19 pandemic and other hazards such as cyclones and floods have highlighted the need for developing a better understanding of the dynamic, complex and systemic nature of risk. To address the varied challenges faced by various local authorities, communities-at-risk and other stakeholders in the management of these aspects of risk require preparing for and reducing the risk in its holistic form. The unforeseen challenges faced in the management of the shelters during cyclones amid the pandemic, which have been discussed in the paper could be addressed by undertaking different interventions, namely, engineering, administrative and individual interventions (CDC, 2020a, 2020b). These include engineering interventions whereby the emergency shelters could be made resilient to multi-hazards such that they ensure that no further harm or risk of the affected population is increased during their stay in the shelters. Such interventions include all aspects undertaken concerning the design and physical infrastructure of shelters toward risk reduction and management. The second set of interventions are administrative whereby policy, process and strategic decisions are undertaken toward the reduction of exposure of the vulnerable population, fulfilling the basic needs of the evacuees, provisioning of emergency supplies, strategizing the layouts and repurposing the available spaces, prevention the creation of new risks of evacuees at the shelter. The third set of interventions are those that could be undertaken at an individual level by the community-at-risk, other involved stakeholders to mitigate their own risk at the shelters such as practicing physical distancing norms, respiratory and hygiene etiquettes, etc. However, individual interventions need to be ensured through proper awareness generation, risk communication and capacity-building measures.

References

Alam, E. and Collins, A.E. (2010), "Cyclone disaster vulnerability and response experiences in coastal Bangladesh", *Disasters*, Vol. 34 No. 4, available at: https://onlinelibrary.wiley.com/doi/abs/10.1111/j.1467-7717.2010.01176.x (accessed 26 August 2020).

AON (2020), "COVID-19: repurposed buildings", available at: www.aon.com/getmedia/af8d8023-7942-4492-b190-1f5a34e8d4dc/COVID-19-Repurposed-Buildings-2020-04-16.aspx (accessed 26 December 2020).

Bosher, L., Dainty, A., Carrillo, P. and Glass, J. (2007), "Built–in resilience to disasters: a pre–emptive approach", *Engineering, Construction and Architectural Management*, Vol. 14 No. 5, pp. 434-446, doi: 10.1108/09699980710780746.

CDC (2020a), "Emergency shelters in disaster response", Centers for Disease Control and Prevention, available at: www.cdc.gov/coronavirus/2019-ncov/global-covid-19/emergency-shelters-low-resource-global.html (accessed 23 December 2020).

CDC (2020b), "Going to a public disaster shelter during the COVID-19 pandemic", Centers for Disease Control and Prevention, available at: www.cdc.gov/disasters/hurricanes/covid-19/public-disaster-shelter-during-covid.html (accessed 24 December 2020).

Das, S., Shaw, R., Kanbara, S., Abe, M. and Komino, T. (2020), *Cascading Disaster: Lessons from South Japan Flood Amidst Pandemic*, CWS Japan, Tokyo, p. 32.

Dasgupta, A. (2020), "A cyclone-battered state struggles with COVID-19 compliance", nature India, available at: www.natureasia.com/en/nindia/article/10.1038/nindia.2020.90 (accessed 24 December 2020).

Dash, B. and Walia, A. (2020), "Role of multi-purpose cyclone shelters in India: Last mile or neighbourhood evacuation", *Tropical Cyclone Research and Review*, Vol. 9 No. 4, available at: www.sciencedirect.com/science/article/pii/S2225603220300576 (accessed 23 December 2020).

Faruk, M., Ashraf, S.A. and Ferdaus, M. (2018), "An analysis of inclusiveness and accessibility of cyclone shelters", *Procedia Engineering*, Vol. 212, pp. 1099-1106, available at: www.sciencedirect.com/science/article/pii/S1877705818301681 (accessed 27 August 2020).

IPR (2020), "Information and public relation department: report on COVID-19", Government of Odisha, p. 38.

Lux, S. (2020), "Acting early in times of a pandemic: the challenge of staying ready for extreme-weather events during COVID-19", IFRC, available at: www.forecast-based-financing.org/2020/06/11/acting-early-in-times-of-pandemic/ (accessed 25 December 2020).

McEntire, D., Mph, C.G. and Peters, E. (2010), "Addressing vulnerability through an integrated approach", *International Journal of Disaster Resilience in the Built Environment*, Vol. 1 No. 1, pp. 50-64, available at: www.emerald.com/insight/content/doi/10.1108/17595901011026472/full/html (accessed 18 August 2020).

Mohanty, S., Chatterjee, R. and Shaw, R. (2020), "Building resilience of critical infrastructure: a case of impacts of cyclones on the power sector in Odisha", *Climate*, Vol. 8 No. 6, p. 73, doi: 10.3390/cli8060073.

NDMA (2019), "National guidelines on temporary shelters for disaster-affected families", available at: https://jalshakti-ddws.gov.in/sites/default/files/Guidelines_temporary_shelters.pdf (accessed 24 December 2020).

NDMA and CDRI (2020), "COVID-19: impacts and responses, the Indian experiences", NDMA, Government of India, p. 52.

Ober, K. (2020), "Complex road to recovery: COVID-19, cyclone Amphan, monsoon flooding collide in Bangladesh and India", Refugees International, available at: https://reliefweb.int/report/bangladesh/issue-brief-report-complex-road-recovery-covid-19-cyclone-amphan-monsoon-flooding (accessed 24 December 2020).

OSDMA (2012), *Handbook: For Management and Maintenance of Multipurpose Cyclone/Flood Shelters*, Odisha State Disaster Management Authority.

OSDMA (2014a), "Managing cyclone Phailin: converting experience to action", available at: www.osdma.org/publication/managing-cyclone-phailin/#gsc.tab=0 (accessed 27 August 2020).

OSDMA (2014b), "Towards a disaster resilient Odisha: a journey from super cyclone 1999 to Phailin 2013", available at: www.osdma.org/publication/towards-a-disaster-resilient-odisha/#gsc.tab=0 (accessed 22 August 2020).

OECD (2019), "Good governance for critical infrastructure resilience", *OECD Reviews of Risk Management Policies*, OECD Publishing, Paris.

PAHO (2020), "Caribbean shelter guide: COVID-19 considerations", available at: https://iris.paho.org/bitstream/handle/10665.2/52170/PAHOPHECPICOVID-19200020_eng.pdf?sequence=5&isAllowed=y (accessed 26 December 2020).

Petit, F., Buehring, W., Whitfield, R., Fisher, R. and Collins, M. (2011), "Protective measures and vulnerability indices for the enhanced critical infrastructure protection programme", *International Journal of Critical Infrastructures*, Vol. 7 No. 3, pp. 200-219.

Private Sector Alliance for Disaster Resilient Societies (ARISE), UNDRR (2017), "Critical infrastructure and disaster resilience: issue brief by private sector (ARISE)", available at: https://reliefweb.int/sites/reliefweb.int/files/resources/55922_55922criticalinfrastructureanddisas.pdf (accessed 27 July 2020).

Special Relief Commissioner, Government of Odisha (2020), *Final Memorandum on Super Cyclonic Storm "Amphan"*, Revenue and Disaster Management Department.

SRC (2020), "State relief commissioner report on cyclone Amphan", Government of Odisha, p. 23.

T.V.Pandya (2020), "When natural disasters cross the path of COVID-19", EOS, available at: https://eos.org/ (accessed 25 December 2020).

United Nations Office for Disaster Risk Reduction (2015), "Sendai framework for disaster risk reduction 2015-2030", available at: www.undrr.org/publication/sendai-framework-disaster-risk-reduction-2015-2030 (accessed 5 August 2020).

United Nations Office for Disaster Risk Reduction (2017), "Terminology", available at: www.preventionweb.net/terminology/view/51751 (accessed 28 July 2020).

UNOCHA (2020), "Cyclones in the time of COVID-19", Prevention Web, available at: www.preventionweb.net/news/view/72923 (accessed 23 December 2020).

Wedawatta, G., Kulatunga, U., Amaratunga, D. and Parvez, A. (2016), "Disaster risk reduction infrastructure requirements for South-Western Bangladesh: perspectives of local communities", *Built Environment Project and Asset Management*, Vol. 6 No. 4, pp. 379-390, available at: www.researchgate.net/publication/307601782_Disaster_risk_reduction_infrastructure_requirements_for_South-Western_Bangladesh_Perspectives_of_local_communities

Further reading

Information and Public Relations Department, Government of Odisha (2020b), "Press release", Department of Health and Family Welfare, available at: https://health.odisha.gov.in/pdf/news-covid-19-press-20meet-20082020Eng.pdf (accessed 21 August 2020).

Information and Public Relations Department, Government of Odisha (2020b), "Press release", Department of Health and Family Welfare, available at: https://health.odisha.gov.in/pdf/news-covid-19-press-meet-20052020Eng.pdf (accessed 31 July 2020).

Intergovernmental Panel on Climate Change (2012), "Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation. A Special Report of the Intergovernmental Panel on Climate Change", Cambridge University Press, available at: www.ipcc.ch/report/managing-the-risks-of-extreme-events-and-disasters-to-advance-climate-change-adaptation/ (accessed 8 August 2020).

National Disaster Management Authority (2020), "About NCRMP", National Cyclone Risk Mitigation Project, available at: https://ncrmp.gov.in/about-ncrmp/ (accessed 20 August 2020).

National Disaster Management Authority, Coalition for Disaster Resilient Infrastructure (2020), "Response to COVID-19: Odisha", available at: https://ndma.gov.in/images/covid/response-to-covid19-by-odisha.pdf (accessed 18 August 2020).

Odisha State Disaster Management Authority (2020), "Multipurpose cyclone/flood shelters", available at: www.osdma.org/preparedness/early-warning-communications/satark/#gsc.tab=0 (accessed 26 August 2020).

Office of Special Relief Commissioner, Government of Odisha (2020), "Preparedness for impending cyclone over Bay of Bengal", Odisha State Disaster Management Authority, available at: www.osdma.org/wp-content/uploads/2020/05/2692.pdf (accessed 25 July 2020).

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Yoga and stress management during and post COVID-19 urban lifestyle in Japan

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ABSTRACT

When COVID-19 started spreading in Japan, the government announced national emergency in April-May, and requested people to stay inside home for a prolonged period of time. This has caused significant stress in different groups of urban residents in Japan, where close contacts were the key issue. An online survey conducted with urban residents have pointed out that 78% were under stress, and 18% were using yoga to relieve from the stress. Although the percentage of people conducing yoga was less, but they wanted to continue it even after the COVID-19 is over. With some literature review, the paper argues yoga as an effective means of stress and health management during as well post Corona time. This is especially relevant to urban lifestyle, since yoga can be done by any age group, including physically challenged people. It is argued that yoga can also release stresses in different disaster situation, especially in the evacuation centers.

Key words: COVID-19, yoga, stress management, urban lifestyle, healthcare

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INTRODUCTION

In December 2019, an outbreak of coronavirus infection (COVID-19) was reported in Wuhan City, North Province, People's Republic of China, and has infected significant number of people causing death, severe health problems, impacts of economies, livelihood and lifestyles. Japan, with its close proximity to China, high volume travel between the two countries, high urban density and relatively higher percentage of aged population is considered vulnerable to this global pandemic from the initial stage [1, 2]. On April 7, 2020, the Government of Japan revised the state of emergency, judging that "a situation has occurred that could have a tremendous impact on the people's lives and the national economy due to the nationwide and rapid spread of the disease. Based on the provisions of Article 32, Paragraph 1 of the Act on Special Measures Concerning Influenza, etc." Unlike other countries, the state of emergency in Japan is not a forced lockdown, rather a request to its citizen to refrain from going out, maintaining basic social norms and protection measures, reduction of economic and social. Before calling for nation wide emergency, several prefectures including Tokyo Metropolitan Government, Hokkaido (the northern island) has declared its prefectural emergency and made the same request to its people to observe certain levels of restrictions. This was one of the first attempt in recent years that the Japanese Government has called for national emergency due to pandemic, which is considered as a biological hazard.

In addition to the economic stagnation, more than 100 million people stayed in the home for more than a month including all ages like infants, school children, working people and the elderly. In other words, the fight against this unprecedented virus has resulted in the burden of lack of exercise and stress on healthy people, who did not have any symptoms of the virus. The stress caused by refraining from going out causes social and family problems such as domestic violence, and the increase in suicides due to financial instability is already anxious [3]. The stress and lack of exercise associated with these self-restraint from going out, often termed as "corona blue", have become a problem not only for adults who work from home, but also for children who cannot go to school, and to elderly people who cannot go to day care services.

On April 22, 2020, two weeks after the state of emergency was announced, a government expert meeting discussed measures against the new coronavirus and proposed to reduce contact with people by 80% as "situational analysis" and "proposal") [4]. The expert panel recommended 10 points for online activities for muscle training and yoga. As a result, it became a proposal to relieve the mental and physical stress using yoga that can be done online at home and maintain wellness. Different academic institutes, including Keio University has also decided to introduce video yoga lessons as a mean to maintain the wellness of the mind and body at homes when students refrain from going out. In this way, yoga found its new niche in urban lifestyle to combat the unprecedented large-scale and long-lasting impacts of COVID-19. In addition, as we are seeing multiple waves in COVID-19 in different parts of the world, including Japan (which is under third wave from October 2020), the world may continue to be intermittently and partially refrained from going out or banned from going out for which will also cause prolonged stress.

In this context, the paper examines the importance and usefulness of yoga for effective stress management, with specific focus on urban residents. With an online survey conducted in Japan, the paper argues that in the urban lifestyle during as post COVID-19, yoga can play an important role in stress management, as well as overall health management.

YOGA AND ITS EFFECTS ON HEALTH AND STRESS MANAGEMENT

Yoga is defined as "stopping all activities of the mind and mind (chitta)" (MOA 2017, p 4-5) [5]. This section describes the medical science related argument for effectiveness of Yoga. Our minds are influenced by the physical world and are in a state of confusion and suffering every day. Minds and thoughts are constantly changing, and yoga is the task of completely stopping change while controlling the changing mind. With yoga, one can free oneself from the state of mind that is trapped in that suffering and binding (MOA 2017, p 4-5) [5]. By stopping the movement of one's mind, one can reach a state of enlightenment and control it in a calm state. Yoga is to calm one's mind and free oneself from the painful conditions of confusion. In other words, yoga is a mental activity aimed at calming the mind and body. In addition to using various asanas (poses), pranayama (breathing), meditation (meditation), yoga is a healthy and lively lifestyle with a balanced approach to life [5]. It makes the most of the ability of yoga breathing (pranayama) and meditation to balance the sympathetic and parasympathetic nerves. The stress hormone cortisol has emerged as the true nature of stress. It has been found that high levels of cortisol secreted by long-lasting stress reduce the processes of nerve cells in the hippocampus of the brain. The hippocampus is the part that controls memory and is involved in emotions. It has become apparent that damage can lead to dementia and depression. Yoga breathing is an effective way to solve this [6]. Numerous researches have pointed out scientific value of yoga on health management.

In addition, the program "Mindfulness", which was born based on yoga meditation, is attracting attention as a method of preventing mental illness caused by breathing [7]. Mindfulness meditation and reduced breathing can help calm the amygdala and manage stress [8]. Because the respiratory center is close to the pituitary gland, yoga control of the pituitary gland calms the pituitary gland and suppresses cortisol secretion from the adrenal cortex to reduce stress. Pranayama can reduce blood flow in the pituitary gland and reduce stress.

It is said that serotonin levels are low in stress and depression. Serotonin is a transmitter that suppresses the runaway of noradrenaline and dopamine and balances the mind. The serotonin nervous system exists as tens of thousands of cell bodies in the raphe nuclei in the midline of the brainstem, and its axons project to a wide range of brain regions from the cerebral cortex to the spinal cord, affecting various brain functions [9]. Therefore, mental stability can be obtained by increasing serotonin. In particular, the spontaneous firing mode of serotonin nerves has the following characteristics. Regular impulse firing continues at a few hertz during awakening, with slow-wave sleep firing sparsely and irregularly, and REM [rapid eye movement sleep] sleep with complete firing arrest. In other words, it works on the cerebral cortex and has various functions such as making one feel refreshed when wake up, making one's body active when wake up in the morning, suppressing the sensation of pain, and working on anti-gravity muscles. When serotonin is low, these functions do not work well, making it harder to get up and making it easier to feel pain in trivial matters. Serotonin is said to increase through a regular life, exposure to light, and rhythmic exercises such as dancing and jogging [10].

[11] a professor of integrated physiology at Toho University School of Medicine, conducted Zen yoga breathing exercises for people who had no experience in zazen and observed the appearance of alpha waves [11]. Among the α waves (8-13Hz), the high-frequency α2 component (10-13Hz) increased significantly, theta waves decreased, and β waves did not show significant fluctuations. The point to note about the appearance of alpha waves during awakening is that anyone who closes their eyes immediately becomes an alpha wave-dominant brain wave [12]. Therefore, we tried Zen yoga breathing even when the eyes were closed (note that the above data is in the open state). Since the eyes are closed, a high peak of the α wave is observed from the beginning. The α wave (corresponding to the low frequency α1 component) disappears at about 7 minutes of the breathing method, and instead, at 4-5 minutes of the breathing method, a new α2 component appears and is gradually enhanced. That is, it was considered that the Zen yoga breathing method changed the arousal state of the brain waves and the cerebral cortex through a pathway in the brain different from that by closing the eyes. [13]. It is rhythmic exercise that further enhances serotonin neural activity in the awake state. Yoga, the rhythmic movement of breathing, enhances the impulse firing of serotonin nerves.

Yoga seems to be used by wider variety of people and professionals from different section of the society. Tom Brady's health regimen would not be complete without a healthy dose of ancient Eastern wisdom. He is a hardcore lover of yoga, which he gives credit for miraculous mental and physical benefits: “It’s great for flexibility, it’s therapeutic, and great for your attitude.” Sports personnel, including Major League baseball players, soccer players, sumo wrestlers are found to be using yoga increasingly for both their stress and health management [14]. In Japan, yoga is gradually introduced to elementary, junior and middle high schools as a part of extra-curricular activities. Self Defense Forces in Japan, including Maritime Self Defense team are also using yoga when they need to spend longer time in the

COVIDS-19 STRESS MANAGEMENT

In the world, several countries like China, Italy, France, other EU countries, UK, USA, Russia, Canada, Indian have taken policies such as lockdown and refraining from going out at periodic and spatial ways over last several months. This put billions of people under house arrest for weeks and months at home. This first-ever global experience of lockdown in March 2020 was repeated in the form of second and third waves over the next few months. In other words, this research is characterized by studying the fight against stress caused by the historic number of people under house arrest for the first time in history, also to enhance a better preparedness for similar disasters in the future. This is related to stress management method from the standpoint of disaster prevention and early recovery. People, including celebrities in different countries have been engaged in indoor family or self-activities like cooking, indoor exercise or workout, web concerts etc. to release their stresses, and this can be viewed through numerous social media posts over last several months.

There are several researches on COVID-19 related stresses. The level of stresses varies from people to people, sometimes based on the age, occupation etc. The importance of psychosocial assessment and monitoring is highlighted by [15], and argues that the assessment should include queries about Covid-19–related stressors (such as exposures to infected sources, infected family members, loss of loved ones, and physical distancing), secondary adversities (economic loss, for example), psychosocial effects (such as depression, anxiety, psychosomatic preoccupations, insomnia, increased substance use, and domestic violence), and indicators of vulnerability (such as preexisting physical or psychological conditions).

Different tips are provided through different research for stress management during COVID-19. A few can be listed as follow: healthy eating habit, creative physical exercises, social connectivity, practicing kindness, enough time for rest and relaxing, focusing on mindfulness etc. Integrative consideration of COVID-19 also emphasizes on stress management, and urged the importance of mindfulness techniques such as meditation, breathing exercises, guided imagery, etc. [16]. In a survey of around 1000 Chinese college students, [17] have pointed out different types of stresses during isolation in COVID-19 period. The study argued that long isolation can have negative consequence on the mental stress among young generation, and have suggested six step intervention strategy, including delivery of appropriate risk information and enhancing knowledge on stress management among others.

Role of yoga in stress management has also been emphasized by several authors. [18] emphasized on the importance of shortage of yoga trainer and argued that yoga practice is actively sought to achieve reduced anxiety and stress so that improved sleep may positively impact immunity. They also argued the importance of social media in spreading online yoga and its usefulness in stress management and highlighted the effectiveness of yoga in working from home stress management. [19] also argued the importance of yoga and Ayurveda as alterative public health approach for COVID-19 health management. Arguing that poor mental health condition including stress and depression, are known to increase the risk of acute respiratory infections, the paper argued that several measures for mental health are described in yoga therapy, including pranayama (breathing exercise) which enhances lung function. Meditation is found to reduce inflammation markers and influence markers of virus-specific immune responses.

SURVEY IN JAPAN

To understand the stress issues among wider urban residents in Japan, a questionnaire survey on stress management and yoga practice during COVID-19 period was organized by Keio University and Yoga organization of Japan during 15th of May to 15th of June 2020. The survey was conducted online using promotion through different social media and website. A total of 336 people responded to the survey with different age groups and nationalities (mostly Japanese, but also India, USA and others, who are residing in Japan). Female % of the respondents were higher with 63%. 51% of the respondents are of the age group between 20s and 30s, followed by 23% of 40s and 50s, and 20% under 20s.

Figure 1 shows the results of the survey. It seems that 78% of the respondents are feeling some kind of stresses during COVID-19. The stress is exemplified in the form of different health impact like clod limbs, dizziness, less appetite, irritation, out of breath etc. Financial issue, fear of infection, isolation from society, are some of the causses of stress. People use different ways to release stresses like sports, stretching, yoga, as well as reading etc. Around one third of respondents used to conduct yoga before the pandemic, with a small percentage (18%) were conducting yoga for stress management (Figure 2).

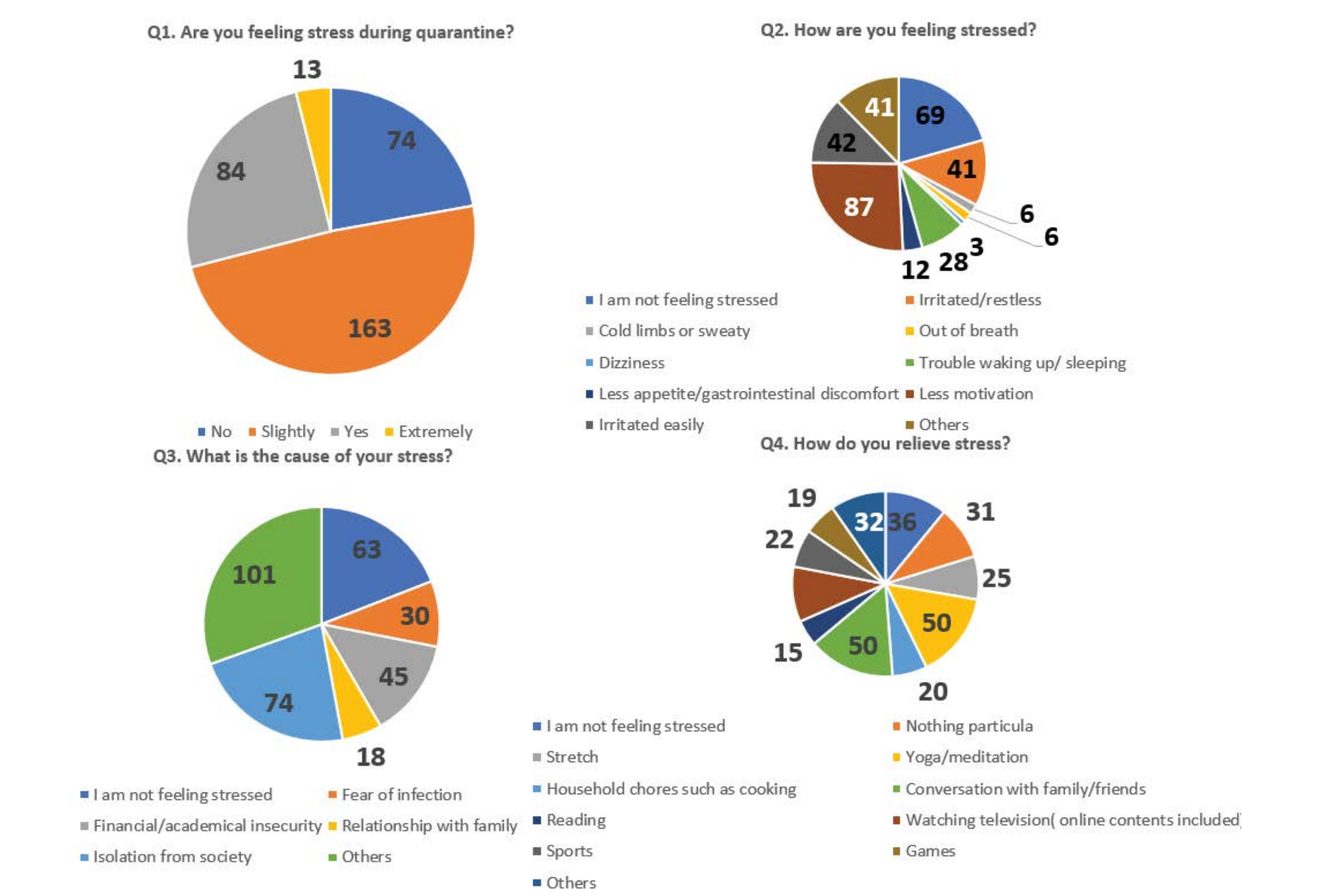

Figure 1: Feeling stress and ways to release stress.

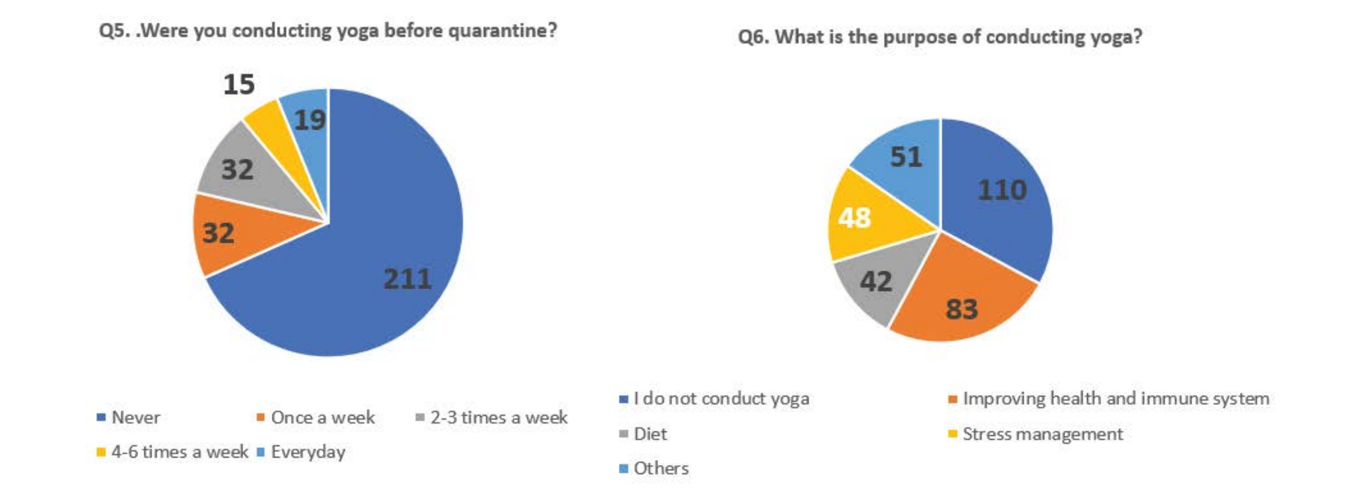

Figure 2: Performing yoga before and during COVID-19

Those who conducted yoga, usually does it once a week or 2-3 times a week (Figure 3). From the survey, it is found that 54% of people who practice yoga, do yoga by themselves, and 36% of people who practice yoga using online platform, including you tube (Figure 3). Usual time is 5-10 minutes and 10-30 minutes (Figure 4). The survey also showed that 37% are doing yoga aiming at improving immunity, and 21% are doing it for stress management (Figure 4). To a question whether they want to continue yoga after COVID-19, 17% responded positively, especially for the purpose of stress management. A minor percentage (2%) intend to use yoga to improve cardiopulmonary function, while 10% wanted to continue yoga to maintain being slim and good physique.

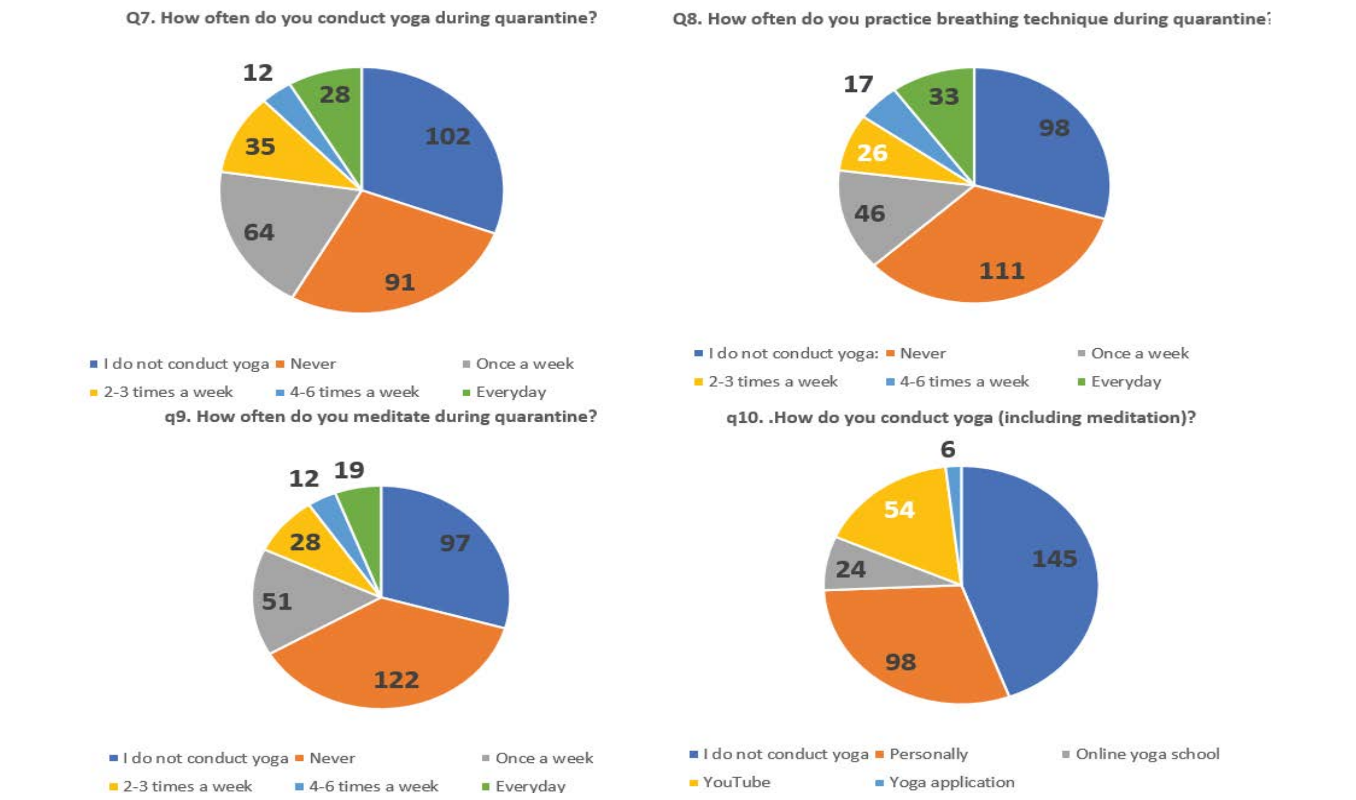

Figure 3: Performing yoga and meditation during COVID-19

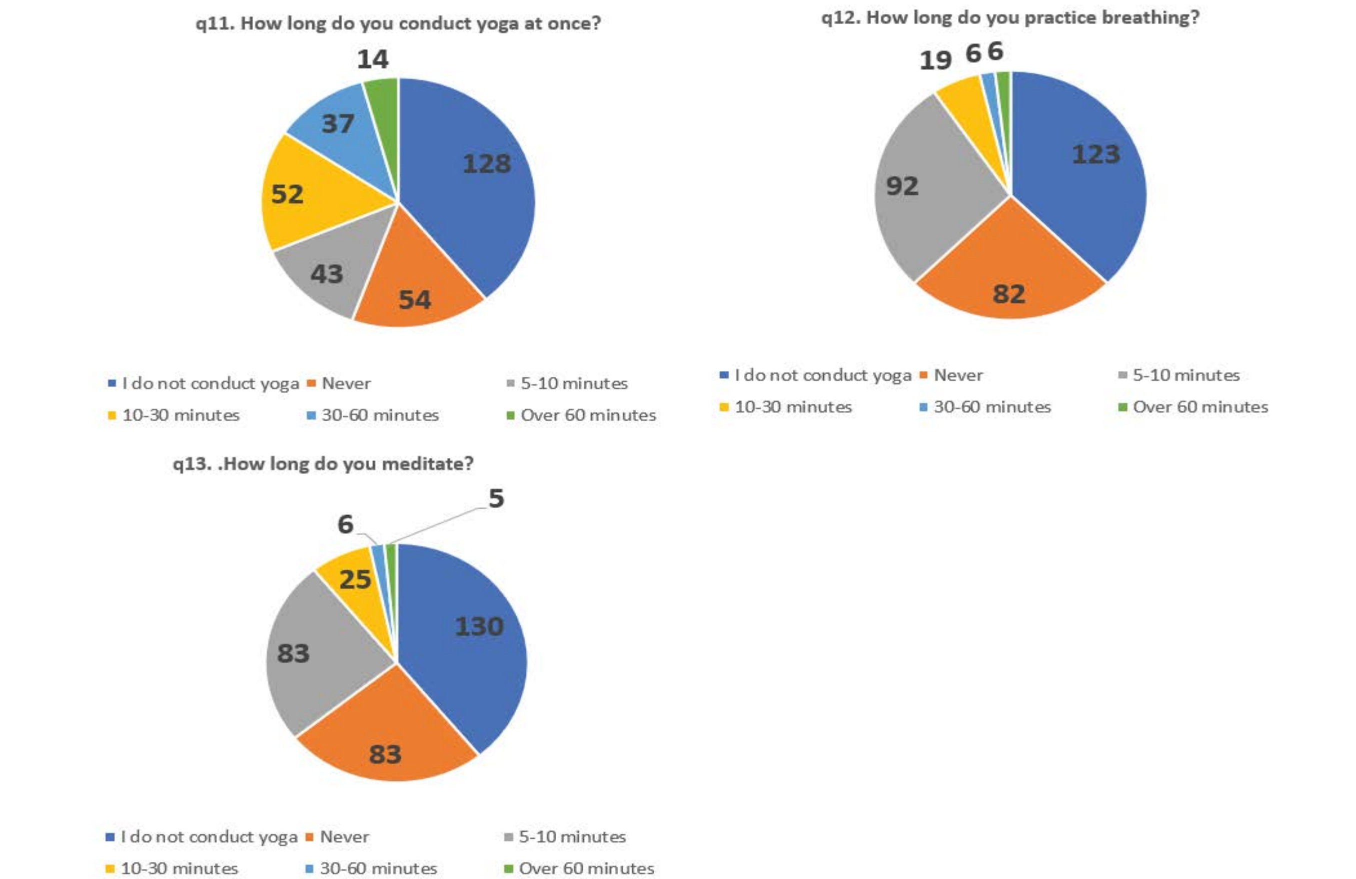

Figure 4: Timing of performing yoga and meditation

DISCUSSION

Currently, not only Japan but the world is facing the onslaught of new coronavirus infections. Each country has focused on stopping the spread of the infection, even if it suspends its economy, industry and education, and as a result, working from home by refraining from going out has become a norm, and our lifestyle has changed significantly. Under the circumstances where it is difficult to accept patients in hospitals because of over-crowded healthcare systems, different virtual ways of communication methods such as telework, take-out, online shopping, mail order, etc. are getting popular. Social change is accelerating due to the psychological effects of anxiety and fear of being unable to meet people. In the future, even if the epidemic of the new coronavirus infection is settled, it is thought that the lifestyle with physical distance as a new countermeasure against infectious diseases will remain the same. Therefore, it is required to propose changes in urban lifestyles, focusing on people's health and happiness, and how to have a sustainable lifestyle in the future.

As a characteristic of urban lifestyle, there is a tendency to like queues and crowds. Events such as parties, dining out, museums, concerts, etc. are great pleasures of the urban lifestyle, and while stimulating the exchange of different cultures with exciting knowledge and technology, we seek nature and relaxation in rural areas. However, during pandemic, these events themselves were restricted, depriving people of the pleasure of going out. Physical distance has become a new manner, and online gatherings, shopping, and browsing have progressed, depriving the characteristic enjoyment of urban lifestyles. The drastic reduction in opportunities to express oneself in relation to others has made it difficult to satisfy the desire for self-approval from status appeals and group appeals, and the altruistic value of branded products and luxury products among consumers has also declined.

In addition, social infrastructure such as transportation, cityscapes, and lifelines support urban lifestyles. Even if the houses are small in size in urban areas in Japan, many people commute to work comfortably in an office building equipped with air conditioning control. However, due to the request to refrain from going out, the population of commuters concentrated in the city decreased, and they were forced to stay in a small house. It doesn't require long commute times and doesn't move. Under these circumstances, the value of urban social infrastructure has declined rapidly, and many companies have lost the meaning of renting offices in buildings at high rent.

The concept of care and cure got its new position in urban lifestyle due to pandemic. While people go to hospitals and health centers for getting cured, it is increasingly becoming important to make proper health care measures which prohibits disease, and also enhance immunity and reduces stresses in a busy urban lifestyle. From the above survey results, it is observed that while there is a significant urban resident in Japan who were felling stress during the CVOID-19 pandemic, not that many people were practicing yoga. The history of yoga in Japan date back to the year 806 during Tang Dynasty, however, the recent days yoga started when Tempu Nakamura practiced yoga in 1919 and started teaching it. Yoga has been popular among the female urban residents over years, which has been mainly used as a mean to stay slim and fit. The yoga movement in Japan got the boost with the start of International Yoga Day in 2015 by Government of India, which promoted yoga globally as a soft power tool. Yoga Organization of Japan has been strongly promoting yoga among different age groups and professionals, including national diet members.

It is interesting to note from the survey that those who were doing yoga could find it to be effective means for stress management. Similarly, yoga can also be effective against the harmful effects of lockdown and refraining from going out. The benefits of performing yoga can be summarized as: 1) one can practice yoga indoor and by alone, 2) All generations (elderly, middle-aged, elementary, junior high and high school, infants) can practice yoga, 3) prevents the risk of illness due to lack of exercise, 4) avoiding personal and family crises due to stress, and 5) yoga is possible for people with disabilities.

The following points should be kept in mind when creating a future COVID-19 yoga program: 1) regularly train your lungs with breathing exercises (prevention), 2) eliminating lack of exercise by asana (pose), 3) immunity boosting and stress release by asana, 4) relieve stress by meditation, 5) immunity boosted by Ayurvedic diet, and 6) reducing economy class syndrome due to asana. In addition, from the perspective of disaster prevention yoga, it is necessary to carry out yoga programs from pre-disaster prevention. Performing yoga on a regular basis is a measure against COVID-19. In addition, regarding disasters other than corona, it is necessary to make policy recommendations to create and disseminate a yoga program to maintain physical and mental health and wellness in the event of a disaster, especially in the evacuation centers.

CONCLUSION

The study focused on the urban residents during COVID-19 pandemic and looked at the stress people were facing. The online survey pointed out that while significant percentage of people are undergoing stress, only one fifth practiced yoga as a stress management reliever. However, those who have practiced yoga wanted to continue it even after the pandemic is over. The paper also argues that in Japanese urban lifestyle, stress is a significant part, with or without Corona. Therefore, practicing yoga as a part of urban lifestyle helps in reducing the stress, enhances immunity against diseases and enhances physical fitness. Since yoga and meditation can be practiced anywhere by any age groups, including people having disabilities, this can be a part of healthy lifestyle. Yoga can be considered as a part of "care" system, which will reduce the pressure on the "cure" systems in the hospital and health centers.

AUTHOR CONTRIBUTION

A.K. contributed to survey, analysis and initial writing of the draft. R.S. contributed to conceptualization, initial writing. Both the authors have read and agreed to the current version of the manuscript.

REFERENCES

1. Shaw R., Kim Y and Hua J.(2020): Governance, technology and citizen behavior in pandemic: lessons from COVID-19 in east Asia, in Progress in Disaster Science, http://dx.doi.org/10.1016/j.pdisas.2020.100090
2. Tashiro A. and Shaw R. (2020): COVID-19 pandemic response in Japan: what is behind the initial flattening of the curve? Sustainability, 12, 5250; doi:10.3390/su12135250
3. Mainichi Shimbun (2020): I can't meet loneliness "" Anxiety and stress ". Rapid increase in consultations. Various backgrounds and detailed care (in Japanese), accessed from: https://mainichi.jp/articles/20200424/k00/00m/040/178000c, Accessed on December 21, 2020
4. MHLW (2020): Ministry of Health, Labor and Welfare: 10 points to reduce contact with people by 80%, in Japanese, accessed from: https://www.mhlw.go.jp/content/10900000/000624038.pdf, accessed on 15th of December 2020
5. MOA (2017): Ministry of Ayush, Government of India, "Certification of Yoga Professionals Official guidebook", 338 pages, Government of India press
6. NHK (2020): NHK, "Protect your brain from the 2nd stress-How to deal with the latest science-". NHK Special "Series Killer Stress" 2nd content, in Japanese, accessed on December 15, 2020.
7. Harvard Business Review (2015): Mindfulness keep your brain healthy, in Japanese translation, accessed from: https://www.dhbr.net/articles/-/3331?page=2, accessed on 14th December 2020
8. NHK (2019): NHK 3rd Production Unit (Science), "NHK Gatten: Lowers blood pressure easily: Strongest trick". Shufu to Seikatsusha, in Japanese, p85, 2019
9. Tanaka S. (2020): "Happy Hormone" Serotonin", Toho University Medical Center Omori Hospital Clinical Laboratory Department, accessed from: https://www.lab.toho-u.ac.jp/med/omori/kensa/column/column20141027.html, accessed on 16th December 2020
10. Masuo Y. (2020): Stress and brain: Department of Biology, Toho University, accessed from www.toho-u.ac.jp, in Japanese, accessed on 14th of December 2020.
11. Arita H. (2009): "From Basic Medicine, Rhythmic Exercise Activates Serotonin Nervous System" in Japanese, Nihon Medical News, pp38-42.
12. Miyazaki S. (2017): "Stress Occurrence and Response" Kinki University Atomic Energy Research Institute Annual Report, in Japanese, Volume 54.
13. NMS (2009): Nippon Medical Shinposha No.4453 (August 29, 2009) Rhythmic movement from basic medicine is serotonin Activates the nervous system, in Japanese.
14. Sportstar (2020): Top 15 Athletes Who Do Yoga, accessed from: https://www.thesportster.com/entertainment/top-15-athletes-who-do-yoga/, accessed on 15th December 2020
15. Pfefferbaum B. (2020): Mental health and COVID-19 pandemic, in The New England Journal of Medicine, accessed on 15th December 2020, accessed from: https://www.nejm.org/doi/full/10.1056/NEJMp2008017
16. Alschuler L., Well A., Horwitz R., Stamets P., Chiasson A., Crocker R., Maizes V. (2020): Integrative consideration during COVID-19 pandemic, in Explore, November-December 16 (6): 354-356.
17. Chen B., Sun J., and Feng Y. (2020): How Have COVID-19 Isolation Policies Affected Young People's Mental Health? – Evidence from Chinese College Students. Frontiers in Psychology, 11, 1529, DOI: 10.3389/fpsyg.2020.01529
18. Sharma K., Anand A. and Kumar R. (2020): The role of yoga in working from home during COVID-19 global lockdown, in Work, vol. 66, no. 4, pp. 731-737
19. Tillu G., Chaturvedi S., Chopra A. and Patwardhan B. (2020): Public health approach of Ayurveda and Yoga for COVID-19 prophylaxis, in The Journal of Alternative and Complementary Medicine Vol. 26, No. 5 https://doi.org/10.1089/acm.2020.0129

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Commentary

Reflection of Challenges and Opportunities within the COVID-19 Pandemic to Include Biological Hazards into DRR Planning

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Abstract: COVID-19 has reinforced the need to revisit the integration of health within disaster risk reduction (DRR) strategies for biological hazards in a system-wide approach. In November 2020, DRR experts attended the Asia-Pacific Partnership for Disaster Risk Reduction (APP-DRR) Forum to share progress and learnings in the areas of health system resilience, data management, residual risk management, risk communication, digital literacy, and knowledge product marketing. Advancements for health in DRR included the importance of multi-sectoral, multi-hazard action plans; adaptation to technological advancements in data collection, dissemination and protection; promoting the health and wellbeing of essential and nonprofessional workers; and improving inclusivity in digital literacy. COVID-19 has affected progress towards the Sustainable Development Goals (SDG) and created a unique opportunity within DRR to re-evaluate the adequacy of response mechanisms against concurrent, cascading or interacting risks of future biological hazards. Health emergency disaster risk management (Health-EDRM) is a new World Health Organization paradigm that includes DRR at intra-, inter- and multidisciplinary levels. Scientific advancement under Health-EDRM is necessary for health and non-health actors in DRR education and research. Continuous education on the multifaceted risk governance is a key to building awareness, capacity and accelerating towards achieving the international DRR and the SDG targets.

Keywords: health-EDRM; disaster risk reduction; biological hazards; Sendai Framework; COVID-19, pandemic

1. Introduction

The intersection between health, resilience capacity building and disaster risk reduction (DRR) planning and strategies has emerged as an interdisciplinary field of great importance for the protection of human health and wellbeing [1] since the publication of several international frameworks, including the Sendai Framework for disaster risk reduction 2015–2030 [2], and more recently in World Health Organization (WHO) Framework for Health-Emergency Disaster Risk Management Framework (Health-EDRM) [3]. The ongoing COVID-19 pandemic has amplified the need to bring the health sector front-and-center in disaster risk management at national and international levels. A hazard is defined by the United Nations Office for Disaster Risk Reduction (UNDRR) within the Hyogo Framework for Action as “a potentially damaging physical event, phenomenon or human activity that may cause the loss of life or injury, property damage, social and economic disruption or environmental degradation. Hazards can include latent conditions that may represent future threats and can have different origins: natural (geological, hydrometeorological and biological) or induced by human processes (environmental degradation and technological hazards)” [4]. A pandemic is an example of a biological hazard, which are hazards that may be either “of organic origin or conveyed by biological vectors”, would be further defined by characteristics such as “infectiousness or toxicity, dose–response, incubation period, case fatality rate and estimation of the pathogen for transmission” [5], and may have amplified impacts in the age of globalization.

Globally, hazard management planning and response strategies have yet to reflect the non-linear transition of biological hazards, particularly pandemics, which can emerge in overlapping waves with different impacts, and the community must enter a response phase before the initial recovery phase is completed [6]. As a result, the non-linear attributes of biological hazards have rendered the human community vulnerable to protracted crises that persist and increase the community’s vulnerability to the cascading risks of multi-hazard that generate complex secondary events and interactions [7]. Many global at-risk communities face cumulative impacts of concurrent geological and hydrometeorological hazard events like earthquakes and cyclones during the COVID-19 pandemic, exacerbating existing issues of food insecurity and social security. Examples of multi-hazards with cascading risks include the cyclone Amphan landfall in India and Bangladesh, which disrupted clean water and sanitation systems, leading to barriers in adequate hand-washing and hygiene, which has, in turn, exacerbated not only the spread of COVID-19 but other waterborne diseases [8]. The Philippines experiences an average of twenty tropical typhoons annually, which has added burden to the emergency situation of the country, leaving many communities to rely on their own resources for protection as local government resources are spent responding to COVID-19 [9]. In addition, many vulnerable communities are affected by syndemics—the concurrent, cascading or interacting risks of biological hazards within the same individuals and groups, thereby aggravating disease burdens such as COVID-19 and an array of noncommunicable diseases [10]. The inadequacy of available risk strategies catered for the nuances of biological hazards will undoubtedly challenge the resilience of community health and health systems.

2. Materials and Methods

This paper delineates the key issues as highlighted at the Asia-Pacific Partnership for Disaster Risk Reduction (APP-DRR) Forum (December 2020) convened by the United Nations Office for Disaster Risk Reduction (UNDRR) Regional office for Asia and the Pacific. This is a multi-stakeholder forum that includes governments, regional inter-governmental organizations, civil society organizations, international organizations and donor organizations. The purpose of the discussions is to monitor the implementation of the Sendai Framework across the region and for stakeholders to share community-relevant insights and identify key priority action areas towards DRR in the region [11].

The way forward for health system resilience building, data management, residual risk management, risk communications, digital literacy, and knowledge product marketing were priority areas identified in this forum and are discussed in this paper.

3. Results

3.1. Health System Resilience

When responding to a biological hazard, the health sector is expected to lead the immediate frontline response. In response to the multifaceted impacts of COVID-19, many jurisdictions mobilized resources outside of the health sector to impose control measures against the spread of the virus, which brought in travel, tourism, education, and other sectors. The most common measures included personal behavioral regulations such as mandatory face masks in public places [12]; social distancing like city lockdowns, quarantine, and school closures [13–15]. Other measures include emergency international travel guidelines, such as self-declaration of health status, and mandatory COVID-19 testing [16–18]. Although the Sendai Framework calls for the broader health system vigilance and resilience and to integrate disaster risk management across primary, secondary, and tertiary healthcare, there is a discord in how national responses are organized to respond to COVID-19. Japan, for example, has a dedicated National Action Plan for Pandemic Influenza and New Infectious Diseases (2013) [19], which provides multi-sectoral, holistic and comprehensive recommendations from the pre-outbreak to the recovery phase. The national action plan proactively monitors outbreaks in other areas of the world, and recommends international joint simulation exercises in the pre-outbreak phase. The plan contains recommendations to ensure continuity of medical care, of education, welfare-services, and business recovery mechanisms. The plan, however, does not consider concurrent, cascading or interacting hazards [6]. In contrast, Singapore's national Pandemic Readiness and Response Plan for Influenza and Other Acute Respiratory Diseases (2014) [20] aims to mitigate the mortality and morbidity consequences after the onset of the first wave through rigid surveillance. The plan mobilizes essential services, case monitoring and isolation mechanisms, and infection control in hospitals so as to maintain healthcare provision. However, the plan is developed by the Ministry of Health and heavily emphasizes the healthcare and public health approach, but is limited in considering the role and responsibility of other sectors [6]. While these plans include guidance on post-epidemic surveillance and the lifting of social and economic restrictions to return to normalcy, neither of these plans takes into consideration the mitigation or treatment of long-term physical, social and psychological impacts of a pandemic, which can include symptoms of anxiety, depression and even posttraumatic stress among healthcare workers or the wider population [21]. In the case of COVID-19, there is evidence of post-viral syndrome, which can include fatigue, myalgia, headaches and shortness of breath [22].

Most of these communities have a primary focus on building resilient health systems and building capacity within health workers to apply DRR approaches in service delivery [2]. Nevertheless, there are broader aspects to consider:

- The capacity of the relevant health and non-health workers across the entire pathway of care should be strengthened, from screening, testing, diagnosis, treatment, recovery and rehabilitation [6];
- Surveillance and information systems must be strengthened to ensure that data collected includes all populations and will enable the system to identify and protect groups facing vulnerability [6];
- Public–private partnership models for health service provision should be explored and promoted to maximize functionality and service provision, especially when government systems are constrained [6].

3.2. Data Management

Biological hazards affect population groups differently, depending on their exposure. Vulnerability will vary according to the nature of the hazard, existing mitigation and protection systems, and any existing and inherent risks faced. Traditional groups facing vulnerability include, but are not limited to, older people, groups living in rural areas, migrant groups, indigenous groups, and those with comorbidities, physical or mental disabilities. In order to assess impact inclusively, baseline pre-disaster data for health and socioeconomic indicators should be made available to identify and minimize the impact of determinants that may exacerbate biological risks [6]. To achieve DRR that is inclusive of the vulnerable and the forgotten, risk assessments during emergency settings must therefore include disaggregated data and analysis for groups facing vulnerabilities such that policies may holistically address the risks of the entire community.

Meanwhile, efforts will be needed to address the challenges in data storage, monetization of data, ethics related to secondary use of data, and implications on personal protection. While sharing timely and accurate data is necessary to the response and containment to a global pandemic, stringent protocols for the secure storage and distribution of data must be implemented, which consider access rights, encryption and continuous review of security, which take into account the evolving benchmark for security and technological advancements [23]. Global data platforms such as Google, Facebook, Uber and cell phone companies have in the past monetized data, for example, in making geolocation data available to scientists for disease spread modeling or similar research. In the case of COVID-19, such information has been utilized for contact tracing or controlling population access to public spaces. In addition, a clear protocol for the management of secondary data is necessary to guarantee a balance between privacy and the usefulness of data [24]. Personal protection is important, and includes mechanisms for identity protection, protection against discrimination, understanding how personal data are used, and informed consent prior to data collection, particularly if the information collected can reveal information related to the health of the individual or their family [25].

3.3. Residual Risk Management

The global response to COVID-19 has highlighted essential workers as a highly exposed group with unique needs. The categorization of essential services varies between jurisdictions, across workforces from healthcare, social work, government services, agriculture, transport, waste management and others. However, despite society's reliance on essential workers, many have been unprotected, working under inadequate health and safety conditions, and putting themselves and their families at risk [26,27]. In many communities, duties of care and protection have been undertaken by nonprofessionals such as informal home care providers [28]. There is a gendered impact of increasing reliance on informal care, which is provided by women in many communities. School closures in Asia, for example, are impacting professional women differently, who provide informal care within families. Travel restrictions have caused challenges and uncertainties to foreign domestic workers, many of whom are women [29]. Informal care providers are often not directly protected by legal measures for health protection or adequate infectious disease control training [30]. In Muslim communities, evidence has shown that women are more likely to wear face coverings in public for religious reasons, but not in their houses while caring for others, while men wear masks for hygiene both inside and outdoors [31]. In identifying and monitoring groups facing vulnerabilities, protection mechanisms can support informal care providers through alternative means like the provision of material resources such as personal protective equipment, medicines; information resources such as home care guidelines; and appropriate training so that they may be able to care for other sick or at-risk groups while minimizing their risk and exposure [6,28].

Under COVID-19, health sectors across countries have resorted to the basic means of service and functionality. The International Labor Organization has published a policy framework on protecting the workforce during the pandemic, which encompasses areas of employment stimulation, supporting enterprises, worker protection and social dialog for solutions [32]. The International Monetary Fund has conducted research on the implication of fiscal policy measures on income inequality within and between vulnerable groups, including essential workers [33]. However, there is little discussion, experience-sharing, and evidence-based lessons learned on the health impact this protract crisis has on essential or nonprofessional workers. With all the new challenges posed by megacities, migration, rural urbanization and technological advancement, what constitutes "essential" workers in a community must be revisited and defined for relevant DRR planning and capacity building.

3.4. Risk Communication

Risk communication can only be made effective when taking the "whole of government, whole of society" approach [3]. The global impact of biological hazards highlights the importance of effective communication between stakeholders at all levels, from the international level, among experts and policymakers, to the community level, within the general public, within households, and among individuals. As the fundamental component to enhancing community cooperation, mobilization and resilience, risk communication should include a top-down approach from government or authorities that participate in cross-country dialog to enable early and effective warning systems. These warning systems should trigger national or international standard operating procedures to mitigate the impact as early as possible [3,6]. Communication also requires the bottom-up input of the whole society to ensure that the information disseminated is tailored and relevant to all members of society and their protection. Efforts should be taken to extend this dialog to groups facing vulnerability, such as indigenous communities, migrants and refugees, for whom information transfer tends to be complex and indirect. The participation and engagement of local government, faith-based groups and religious leaders, as well as civil society groups, are essential in this process [6]. Moreover, it should be recognized that resource information channels vary with user demographics, acceptability, and access. Studies have shown that health literacy and risk perception are negatively correlated with income, education and social status. The European Health Literacy Survey conducted in eight countries demonstrated that 50% of adults have problematic or inadequate levels of access, understanding, appraisal and application of health or risk information [34,35]. A study in Australia showed that people with low health literacy and people whose native language is not English demonstrated poorer understanding of COVID-19 symptoms and prevention measures, more difficulty accessing government information, difficulty accessing prescription medication, and experienced greater anxiousness and financial difficulties [36]. Studies conducted in Australia and the United States showed that factors increasing vulnerability to COVID-19, such as age, underlying chronic diseases, and income are also factors associated with the ability to access and understand health information and decision-making [36,37]. During the COVID-19 pandemic and widespread lockdown, digital media has become a convenient and rapid tool for people to gain information. It is important that risk communication ensure equitable access and understanding by all groups and mitigate against misinformation.

3.5. Digital Literacy

There is growing discussion on the use and functionality of digital tools for information-sharing, contact tracing, and communication. The rapid development of innovative information and communications technology (ICT) has enabled and enhanced the capacity for large-scale data collection, analysis and dissemination. As exemplified during COVID-19, such systems have allowed individuals to remotely conduct normative daily tasks and maintain social cohesion despite extreme physical distancing measures [38]. ICT allows sectors to continue their basic functions, such as the health sector using telemedicine for non-essential patients, the education sector using remote learning, and the business sector to promote teleworking. Furthermore, technology has enabled sectors to conduct extraordinary functions in the context of a pandemic beyond national jurisdiction. For example, governments and private entities have implemented efficient surveillance, reporting, or contact tracing through artificial intelligence other technologies that aggregate and share large-scale data; mapping disease spread for community protection [24].

However, in adopting ICT measures, careful considerations must be made to ensure digital tools are inclusive to all members of the community. For example, barriers of access and adaptability must be considered within ICT infrastructure to guarantee access to information and services among the elderly, disabled groups, lower-income households, or those living in remote areas [6].

3.6. Knowledge Product Marketing

Updating and generating new recommendations and tools for DRR is a continuous process. Outside of science, these tools can be used to develop effective public communication strategies and raising awareness for community preparedness [6]. The DRR community requires more tools and knowledge-sharing platforms to facilitate planning and strategy development [2], and there is as yet limited availability of updated and relevant DRR knowledge product specialization for biological hazards at a global scale such as the COVID-19 hazards. This has hindered knowledge sharing, scenario planning, and cross-sectoral learning. Although the WHO Thematic Platform for Health-EDRM was formed in September 2016 to "coordinate activities, promote information-sharing, develop partnerships, and provide technical advice to strengthen the Health-EDRM research field", as of 2020, there remains an urgent need to strengthen multidisciplinary learning and collaborative efforts to maximize the impact of such knowledge development. Active engagement in shared knowledge and building understanding of the complex nature of biological hazards will enable the DRR community to develop and facilitate scientific risk assessment mechanisms so as to build resilient systems in the future [3].

4. Discussion

The COVID-19 pandemic has had devastating human and socioeconomic impacts worldwide. The global attention received for COVID-19 provides an opportunity for the health and DRR communities to reconceptualize knowledge and tools for disaster risk mitigation, response and recovery. In November 2020, DRR experts from the Asia-Pacific region attended the Asia-Pacific Partnership for Disaster Risk Reduction (APP-DRR) Forum to share progress, policy priorities and opportunities thus far for DRR in the region with respect to the COVID-19 pandemic [11]. Experts shared learnings for risk governance, including health system resilience; data management; residual risk management, risk communication, digital literacy, and knowledge product marketing. Special academic attention has been paid regarding the integration of biological hazards into DRR planning [6]. Although the Health-EDRM Framework was established to ensure that health will be considered within the DRR dialog at intra, inter and multidisciplinary levels, further efforts are required to ensure that both health and non-health actors in education and continuous education are included within DRR frameworks. Notably, and urgently, to include students and young professionals who will become key stakeholders in the next decade in promoting awareness, scientific development, policy, and capacity at the intersection of health and DRR. Successful implementation of the Sendai Framework will require updated Health-EDRM and DRR tools that consider concurrent, cascading and interacting hazards. Cascading risks have a serious impact on national action plans, and the impacts faced are becoming increasingly complex and interdependent. However, national plans still tend to focus on the most probable impacts rather than on those that will bring the most complex consequences that require heavily coherent and coordinated response [7]. Adaptive governance mechanisms are necessary for building interdependent resilience cutting across social, institutional, economic and ecological levels. Reinforcing continuous learning and innovation across the governance of different sectors will strengthen DRR outcomes [39], systematic risks analysis and related action planning. Table 1 summarizes how the above discussion may expand into and impact DRR, related challenges and suggested solutions.

The COVID-19 pandemic has demonstrated the ability for a biological hazard to travel across national borders and the need for governance structures mitigating against transnational risks. There is a role for North-South, and South-South collaboration in jointly developing technological, medical and social innovations, which can accommodate local variation, that lead to creating incentivization for long-term multi-generational resilience [40]. Inter-sectoral coordination such as public–private partnership models for health service provision should be explored to maximize the functionality of service provision and the range of services available [6].

There is a large number of activities, priorities and stakeholders that must be mobilized, facilitated, and coordinated, not only in response to the pandemic and in the recovery phase but also in developing DRR plans against the next hazard that emphasizes a coordinated response across linked sectors rather than over-burdening one sector [6]. In order to operationalize lessons learned in impactful, cost-effective and sustainable ways, methods in cross-program planning, monitoring and evaluation can be taken from the area of project management. This will involve viewing international development as a transformative public sector project when evaluating delivery constraints such as time, cost and quality. International development and private sector projects are at risk of facing similar challenges in poor stakeholder management, cost overruns, inadequate monitoring, and lack of understanding of local context. However, international development projects often have less tangible goals and certainly face higher socio-political complexities that induce further transaction costs [41].

Table 1. Opportunities for different areas to expand into and impact disaster risk reduction (DRR), related challenges and suggested solutions.

Issues	Opportunities to Expand into DRR	Challenges	Suggested Solution
Health systems resilience	• Strengthen health considerations within multi-sectoral national or international DRR action plans • Improve hazard-related health outcomes by revaluating the resilience and vigilance of the health system as a whole	• Weaknesses in current action plans that do not consider the entire disaster cycle or prepare for concurrent, cascading or interacting risks • Weaknesses in current action plans that do not consider multi-sectoral impact or response • Weaknesses in current action plans that do not consider post-epidemic long-term physiological or psychological effects • National bodies are creating unique, siloed national action plans that lack complementarity	• Develop multi-hazard, multi-sectoral and adaptive action plans for DRR • Consider health systems-wide paradigm to care, beyond clinical care • Reinforce awareness-building and continuing professional education as a key component in policy development
Data management	• Identify areas of improvement in existing data platforms (collection, storage, analysis, sharing) in terms of: - Inclusivity of vulnerable groups - Compatibility with other DRR information platforms - Compatibility with technological advancement • Unique opportunity to collect robust post-pandemic data across all populations, to be used in recovery assessment research or for future hazards	• Security considerations in terms of data storage and management • Ethical considerations for data use, monetization of data, and personal data protection	• Consider inclusivity and representation of vulnerable groups in building data management tools • Incorporate the latest technological advancement and adaptive capacities for piloting secure data collection and data management tools • Continuous education regarding systems development and updates
Residual risk management	• Define or redefine "essential" groups, including part-time workers, nonprofessionals (e.g., home care	• There is no standard definition of "essential" workers or nonprofessional workers	• Develop policy and guidelines to protect essential workers and nonprofessional workers

	givers), and non-health sector workers		
	• Research into health impact and health needs of a pandemic on essential workers and nonprofessional workers, in order to build evidence-based policy and guidelines	• Lacking recognition or political will to protect the health and wellbeing of these groups (e.g., material provision, information dissemination)	• Data and research in health impact and needs of essential workers and nonprofessional groups including needs in material resources, information gaps, or training opportunities • Continuous education of stakeholders involved in policy update and development
Risk communication	• Review or strengthen top-down government approaches to early warning systems • Consider health literacy in disaster risk communication and decision-making frameworks • Consider demographic and health factors (e.g., old age, physical disabilities) in ability access to information	• Limited evidence of barriers to inclusivity of populations or inclusivity of communication channels • Limited but growing political will in managing misinformation or in determining the reliability of the information	• Develop inclusive platforms for information dissemination (e.g., used by the elderly, disabled individuals) • Community dialog to review and research barriers of information access and understanding • Building awareness and appropriate policies for communities facing vulnerabilities and improving patterns of communication under complex circumstances
Digital literacy	• Use of novel technology to develop tools for DRR data management (e.g., information sharing, data collection, tracking) • Use novel technology to improve health DRR (e.g., diagnostics, telemedicine)	• Complex access to digital tools for certain groups (e.g., elderly, remote/rural groups, low-income groups)	• Build community dialog to promote the use of digital tools and understand barriers to usage • Pilot novel and innovative tools for telemedicine, robotic temperature monitoring, or automated dispensary • Building awareness and appropriate policies for communities facing vulnerabilities and improving patterns

			of communication under complex circumstances
Knowledge product marketing	• Update Health-EDRM and DRR tools, in particular, to consider the multifaceted and adaptive nature of concurrent, cascading and interacting hazards • Multi-sectoral participation in the development of updated tools and guidelines	• Lack of political or institutional will for multi-sectoral planning	• Collect evidence and lessons learned for needs in addressing novel biological hazards • Develop adaptive tools and knowledge products • Begin a multi-sectoral dialog for DRR • Building awareness and identifying knowledge gaps within communities to encourage active research and policy development

5. Conclusions

COVID-19 has impacted progress across the Sustainable Development Goals (SDG). The economic impact has resulted in an estimated 71 million people pushed into extreme poverty (SDG 1—no poverty); 80 million children under the age of 1 are estimated to miss routine vaccinations (SDG 3—good health and wellbeing); school closures will affect 90% of students (SDG 4—quality education); cases of domestic violence will increase in 30% of countries (SDG 5—gender equality); and 60% of countries will experience prison overcrowding and further risk of spreading COVID-19 (SDG 16—peace, justice and strong institutions) [40].

However, the pandemic also creates opportunities to strengthen SDG, such as strengthening partnerships under SDG 17 in developing shared warning mechanisms, data sharing, multi-stakeholder partnerships in science to build evidence-based policy recommendations. These partnerships can be built between sectors of a country, but also in North–South or South–South cooperation [6].

Opportunities and resources available during the response and recovery of the COVID-19 pandemic may allow DRR stakeholders to examine and evaluate systemic weaknesses in a holistic and comprehensive manner. To ensure that the global population would be more sufficiently protected against future concurrent, cascading, or even interacting hazards, revisiting current DRR plans and strategies within the current framework of biological hazards will be instrumental. The COVID-19 pandemic has created a chance to strengthen partnerships; build mechanisms for a coordinated response between DRR experts and counterparts in health; and build health as a core component across disaster prevention, mitigation, response and recovery. Building understanding of the multifaceted and adaptive components of risk governance within people in their formative years will allow the next-generation to accelerate towards achieving the targets under the Sendai Framework as well as the SDGs. Continuous education, notably of students and young professionals, may be a key component when building awareness about DRR.

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References

1. Chan, E.Y.Y.; Shaw, R. *Health and Disasters: Health Emergency and Disaster Risk Management in Asia*; Shaw, R., Ed.; Springer: Singapore, 2020; ISBN 9780323286657.
2. United Nations International Strategy for Disaster Reduction. *Sendai Framework for Disaster Risk Reduction 2015–2030*; United Nations International Strategy for Disaster Reduction, Geneva, Switzerland, 2015.
3. World Health Organization. *Health Emergency and Disaster Risk Management Framework*; World Health Organization: Geneva, Switzerland, 2019; ISBN 9789241516181.
4. United Nations International Strategy for Disaster Reduction. *Hyogo Framework for Action 2005-2015: Building the Resilience of Nations and Communities to Disasters*; United Nations International Strategy for Disaster Reduction,, Geneva, Switzerland, 2005.
5. United Nations General Assembly. *Report of the Open-Ended Intergovernmental Expert Working Group on Indicators and Terminology Relating to Disaster Risk Reduction*; United Nations, Geneva, Switzerland, 2016; Volume A/71/644.
6. Shaw, R.; Chatterjee, R.; Dabral, A. *Integrating Biological Hazards (Including Pandemics) into DRR Planning: Technical Advisory Document*; unpublished, 2020. Available online: http://www.ccouc.ox.ac.uk/technical-advisory-document-integrating-

biological-hazards-including-pandemics-into-drr-planning (accessed on 21 December 2020).
7. United Nations International Strategy for Disaster Reduction. *Cross-Sectoral and Multi-Risk Approach to Cascading Disasters*; United Nations International Strategy for Disaster Reduction, Geneva, Switzerland, 2017.
8. Ebrahim, S.H.; Rahman, N.M.M.; Imtiaz, R.; Gozzer, E.; Alqahtani, S.A.; Ahmed, Y.; Memish, Z.A. Forward planning for disaster-related mass gatherings amid COVID-19. *Lancet Planet. Health* **2020**, *4*, e379–e380, doi:10.1016/S2542-5196(20)30175-3.
9. Lucero-Prisno, D.E.; Bernardino, G.D.; Camua, A.A.R.; Lin, X.; Adebisi, Y.A. Philippines braces for the typhoon season amidst COVID-19. *Lancet Reg. Health West. Pac.* **2020**, *1*, 100003, doi:10.1016/j.lanwpc.2020.100003.
10. Singer, M.; Bulled, N.; Ostrach, B.; Mendenhall, E. Syndemics and the biosoical concepts of health. *Lancet* **2017**, *389*, 941–950, doi:10.1016/S0140-6736(17)30003-X.
11. United Nations Office for Disaster Risk Reduction Asia-Pacific Partnership for Disaster Risk Reduction (APP-DRR) Forum. Available online: https://www.undrr.org/event/asia-pacific-partnership-disaster-risk-reduction-app-drr-forum-0 (accessed on 27 January 2021).
12. World Health Organization. *Mask Use in the Context of COVID-19*; World Health Organization: Geneva, Switzerland, 2020.
13. Public Health England Guidance on Shielding and protecting People Who are Clinically Extremely Vulnerable from COVID-19. Available online: https://www.gov.uk/government/publications/guidance-on-shielding-and-protecting-extremely-vulnerable-persons-from-covid-19/guidance-on-shielding-and-protecting-extremely-vulnerable-persons-from-covid-19 (accessed on 21 December 2020).
14. Government of Hong Kong New Requirements to Reduce Gatherings. Available online: https://www.coronavirus.gov.hk/eng/reduce-gatherings.html (accessed on 21 December 2020).
15. Centers for Disease Control and Prevention Operating Schools during COVID-19: CDC's Consideration. Available online: https://www.cdc.gov/coronavirus/2019-ncov/community/schools-childcare/schools.html (accessed on 21 December 2020).
16. Government of Hong Kong Points to Note for Quarantine for Inbound Travellers. Available online: https://www.coronavirus.gov.hk/eng/inbound-travel.html (accessed on 21 December 2020).
17. Singapore Ministry of Health Updates on Border Measures and Community Surveillance Testing Operations. Available online: https://www.moh.gov.sg/news-highlights/details/updates-on-border-measures-and-community-surveillance-testing-operations (accessed on 21 December 2020).
18. Public Health England Coronavirus (COVID-19): Safer Travel Guidance for Passengers. Available online: https://www.gov.uk/guidance/coronavirus-covid-19-safer-travel-guidance-for-passengers (accessed on 21 December 2020).
19. Government of Japan National Action Plan for Pandemic Influenza and New Infectious Diseases. Available online: https://www.cas.go.jp/jp/seisaku/ful/keikaku/pdf/national action plan.pdf (accessed on 22 December 2020).
20. Singapore Ministry of Health Pandemic Readiness and Response Plan for Influenza and Other Acute Respiratory Diseases. Available online: https://www.moh.gov.sg/docs/librariesprovider5/diseases-updates/interim-pandemic-plan-public-ver-_april-2014.pdf (accessed on 22 December 2020).
21. Gallagher, M.W.; Zvolensky, M.J.; Long, L.J.; Rogers, A.H.; Garey, L. The Impact of Covid-19 Experiences and Associated Stress on Anxiety, Depression, and Functional Impairment in American Adults. *Cognit. Ther. Res.* **2020**, *44*, 1043–1051, doi:10.1007/s10608-020-10143-y.
22. Davido, B.; Seang, S.; Tubiana, R.; de Truchis, P. Post–COVID-19 chronic symptoms: A postinfectious entity? *Clin. Microbiol. Infect.* **2020**, *26*, 1448–1449, doi:10.1016/j.cmi.2020.07.028.
23. Dubois, C.; Wright, K.; Parker, M. Ethics in Research. In *WHO Guidance on Research Methods for Health Emergency and Disaster Risk Management*; World Health Organization: Geneva, Switzerland, 2020; pp. 185–199.
24. Findlay, M.J.; Remolina, N. Regulating Personal Data Usage in COVID-19 Control Conditions. *SSRN Electron. J.* **2020**, 1–42, doi:10.2139/ssrn.3607706.
25. World Health Organisation Ethics in Epidemics, Emergencies and Disasters: Research, Surveillance and Patient Care. 2015. https://www.who.int/ethics/publications/epidemics-emergencies-research/en/ Available online: (accessed on 22 December 2020).
26. McNicholas, C.; Poydock, M. Who are Essential Workers? Available online: https://www.epi.org/blog/who-are-essential-workers-a-comprehensive-look-at-their-wages-demographics-and-unionization-rates/ (accessed on 22 December 2020).
27. Lancet, T. The Lancet The plight of essential workers during the COVID-19 pandemic. *Lancet* **2020**, *395*, 1587, doi:10.1016/S0140-6736(20)31200-9.
28. Chan, E.Y.Y.; Gobat, N.; Kim, J.H.; Newnham, E.A.; Huang, Z.; Hung, H.; Dubois, C.; Hung, K.K.C.; Wong, E.L.Y.; Wong, S.Y.S. Informal home care providers: The forgotten health-care workers during the COVID-19 pandemic. *Lancet* **2020**, *395*, 1957–1959, doi:10.1016/S0140-6736(20)31254-X.
29. Wenham, C.; Smith, J.; Morgan, R. COVID-19: The gendered impacts of the outbreak. *Lancet* **2020**, *395*, 846–848, doi:10.1016/S0140-6736(20)30526-2.
30. Karlsson, U.; Fraenkel, C.-J. COVID-19: Risks to healthcare workers and their families. *Br. Med. J.* **2020**, *371*, doi:10.1136/bmj.m3944.
31. Yonally, E.; Tulloch, O.; Butler, N.; Gillespie, A. *RCCE Strategies to Overcome Covid-19 Fatigue in the Eastern Mediterranean, Middle Eastern and Northern Africa*; Institute of Development Studies, Brighton, UK, 2020.
32. International Labour Organization. *A Policy Framework for Tackling the Economic and Social Impact of the COVID-19 Crisis*; International Labour Organization, Geneva, Switzerland, 2020.

33. Jurzyk, E.; Nair, M.M.; Pouokam, N.; Sedik, T.S.; Tan, A.; Yakadina, I.; Tan, A.; Yakadina, I. *COVID-19 and Inequality in Asia: Breaking the Vicious Cycle*; International Monetary Fund, Washington, DC, USA, 2020.
34. Okan, O.; Bollweg, T.M.; Berens, E.M.; Hurrelmann, K.; Bauer, U.; Schaeffer, D. Coronavirus-related health literacy: A cross-sectional study in adults during the COVID-19 infodemic in Germany. *Int. J. Environ. Res. Public Health* **2020**, *17*, 5503, doi:10.3390/ijerph17155503.
35. Sørensen, K.; Pelikan, J.M.; Röthlin, F.; Ganahl, K.; Slonska, Z.; Doyle, G.; Fullam, J.; Kondilis, B.; Agrafiotis, D.; Uiters, E.; et al. Health literacy in Europe: Comparative results of the European health literacy survey (HLS-EU). *Eur. J. Public Health* **2015**, *25*, 1053–1058, doi:10.1093/eurpub/ckv043.
36. McCaffery, K.; Dodd, R.; Cvejic, E.; Ayre, J.; Batcup, C.; Isautier, J.; Copp, T.; Bonner, C.; Pickles, K.; Nickel, B.; et al. Health literacy and disparities in COVID-19–related knowledge, attitudes, beliefs and behaviours in Australia. *Public Health Res. Pract.* **2020**, *30*, 1–9, doi:10.17061/phrp30342012.
37. Wolf, M.S.; Serper, M.; Opsasnick, L.; O'Conor, R.M.; Curtis, L.; Benavente, J.Y.; Wismer, G.; Batio, S.; Eifler, M.; Zheng, P.; et al. Awareness, Attitudes, and Actions Related to COVID-19 Among Adults with Chronic Conditions at the Onset of the U.S. Outbreak: A Cross-sectional Survey. *Ann. Intern. Med.* **2020**, *173*, 100–109, doi:10.7326/M20-1239.
38. World Health Organization Digital Technology for COVID-19 Response. Available online: https://www.who.int/news/item/03-04-2020-digital-technology-for-covid-19-response (accessed on 21 December 2020).
39. Munene, M.B.; Swartling, Å.G.; Thomalla, F. Adaptive governance as a catalyst for transforming the relationship between development and disaster risk through the Sendai Framework? *Int. J. Disaster Risk Reduct.* **2018**, *28*, 653–663, doi:10.1016/j.ijdrr.2018.01.021.
40. United Nations. *UN Research Roadmap for the COVID-19 Recovery*; United Nations, Geneva, Switzerland, 2020.
41. Ika, L.A.; Söderlund, J.; Munro, L.T.; Landoni, P. Cross-learning between project management and international development: Analysis and research agenda. *Int. J. Proj. Manag.* **2020**, *38*, 548–558, doi:10.1016/j.ijproman.2020.10.005.

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The impact of COVID-19 pandemic on public engagement approaches to disaster preparedness for foreign residents: case of Tokyo Metropolitan Area, Japan

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Abstract

Purpose – Foreign residents in Japan are classified as one vulnerable group at risk of disasters. Therefore, various measures are in place to engage, educate and offer first-hand experiences of disaster countermeasures required to overcome systematic disaster preparedness problems. However, the need for Japan to prevent the spread and infection of COVID-19 has necessitated measures that prohibit public gatherings and other social activities. This study aims to look at how these arrangements have impacted public engagement approaches to disaster preparedness for foreign residents within the Tokyo Metropolitan Area.

Design/methodology/approach – This study identifies local organizations and examines their methods of engagement that enhance the disaster preparedness of foreign residents in the Tokyo Metropolitan Area. The activities are examined in the context of when there was no COVID-19 pandemic and the current state of the pandemic. A change in activities attributed to the COVID-19 pandemic is then extracted and explained through field surveys and interviews with the relevant organization.

Findings – This study reveals that most disaster preparedness activities were best accomplished through in-person engagements. Nevertheless, online engagements have become the alternative option because of COVID-19 infection prevention. This change has widen the coverage of some activities but major setbacks include events cancelations and technical and technological challenges attributed to using online platforms.

Research limitations/implications – This study did not examine the effectiveness of pre-COVID-19 pandemic engagement approaches and current changes attributed to the pandemic; many public engagement literatures acknowledge success to include the number of participants, the abilities of organizations to find ways to effectively and positively engage their stakeholders for meaningful partnerships, the number of clicks, access to a website and comments made online. Therefore, as organizations in this study have shown a glimpse of the above characteristics, there are indications of some level of effectiveness in their engagement approaches even amid a pandemic.

Practical implications – To avoid such situations in the future, there is the need for the Tokyo Metropolitan Government, local governments and associated organizations to develop public engagement approaches that are flexible to resist or cope with in-person, remote encounters, or sudden circumstances that could potentially derail planned activities.

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Social implications – The most effects attributed to the COVID-19 pandemic are the cancelation of many disaster drill exercises, community disaster walks, training of volunteers for foreign residents' assistance and many hours of "Yasashii Nihongo" lesson. The cancelation of activities is a setback to the efforts of self-help and mutual aid campaigns by authorities to reduce the impacts of disasters.

Originality/value – The spirit of inclusion has been an embodiment of disaster management approaches in Japan for years for which policy recognitions have been tagged along the dimensions of public aid, self-help and mutual aid. These are aimed at engaging the populace, especially foreign residents in disaster training and exercises, language study and other communal activities for disaster preparedness. However, to prevent the spread of COVID-19, there have been a series of restrictions on gathering and inter-personal public engagement activities in Japan. As foreigners are classified as the most vulnerable to disaster in Japan, it is important to understand how these restrictions will/are affecting the efforts of integration and disaster preparedness, which are a crucial part of the Government's effort to reduce casualties and damage in the anticipated Nankai megathrust earthquake. Besides the results being useful for government interventions, it also adds to the knowledge of the repercussion of COVID-19 and how to plan for emergencies.

Keywords Public engagement, Local governance, Disaster preparedness, COVID-19 pandemic, Local organizations, Tokyo Metropolitan Area

Paper type Research paper

1. Introduction

Public engagement is made up of "public" and its "engagement" in collective activities, and when put together, it can be defined as "any individual, group of individuals, organization or institution that has an interest in, or is affected by, the outcome of a decision" (Knowlton, 2013). The processes of public engagement in decision-making are visible in many endeavors such as governance (The Praxis Group, 2012), research (NCCPE, 2017), health (Welsh Government, 2020), infrastructure (House *et al.*, 2017) and many others. The application of public engagement strategies is, however, vital "when a decision is a known concern of other parties or is likely to have a significant impact on the parties" (Government of Alberta, 2014). These elements are consistent with disaster management practices, after the realization that the changing scope of disasters is affecting all governments, societies and people at different intensities such that "the ability of a system, community or society exposed to hazards to resist, absorb, accommodate and recover from the effects of a hazard in a timely and efficient manner" (Joerin and Shaw, 2011) depends on collective effort of all (FEMA, 2011). The blatant acceptance of how disasters affect levels of society in different manners, and the prerequisite need to involve all in the planning and execution of risk reduction strategies, characterizes a "spirit of inclusion," as attributed to public engagement (Knowlton, 2013).

The spirit of inclusion has been an embodiment of disaster management approaches in Japan for years but gained momentum after the 1995 Great Hanshin Awaji Earthquake. Moments after the 1995 Great Hanshin Awaji Earthquake disaster revealed the importance of community and public engagement in disaster risk reduction, as well the evidence of vulnerabilities of foreign nationals in disaster events in the country (Cabinet Office Japan, 2018). These have necessitated policy recognitions tagged along "kojo (public aid)," "jijo (self-help)," "gojo (mutual aid in the neighborhoods)" and "kyojo (mutual aid between strangers)" perspectives (Kitagawa, 2016). They are based on the fact that disasters cannot be stopped entirely, but as first responders, communities and residents play vital roles in reducing the impacts and casualties if appropriate learning measures are created through communities-led countermeasures. A successful implementation of disaster risk management engagement at community levels highly depends on existing local structures and stakeholders who have roots and are already connected within the communities (Shaw, 2012). Hence, within Japanese societies, community engagement in disaster management activities is exceedingly spearheaded by disaster prevention voluntary organizations (jishu bosai soshiki), neighborhood associations (chonaikai), fire control clubs (bosai kurabu), disaster volunteers (saigai borantia) and disaster reduction volunteers (bosai borantia). These groups are somewhat intertwined in broader groups represented in semi- or not-for-profit organizations (Kitagawa, 2016). These groups, together with local governments, train, empower, obtain feedbacks, educate and give first-hand experiences to dealing with disasters and other auxiliary measures which augment disaster management planning and implementation processes. To specifically deal with the plight of foreign residents and potential disaster vulnerabilities, additional initiatives, such as the Multicultural Coexistence Initiative (Tabunka Kyosei) and the Zero Information Refugee Project (Jōhō nanmin zero purojekuto), which aim to foster foreigner–Japanese integration and enhance disaster risk communication, are fully incorporated in these community or public engagement activities.

However, as the world continues to grapple with infections and impacts of the COVID-19 pandemic, one distinct characteristic to prevent its spread is by keeping social and physical distances while avoiding crowded areas. For this, Japan has declared series of state of emergencies (SOEs) to curb the spread of the virus especially in the nation's capital Tokyo, because of its population and rate of infections. Each declaration comes with severe and tougher restrictions of public gatherings because of the detection of new variants of the virus. On the contrary, all these SOEs are guided by the closure of many public places such as schools, gyms, recreational areas and many others. Nevertheless, the same facilities are essential to disaster management activities such as evacuation shelters, grounds for disaster drills and exercises and other communal facilities aimed at promoting disaster preparedness (Shaw and Takeuchi, 2012). The need for continuous learning and understanding of disaster risk reduction through preparedness is highlighted by Kaori Kitagawa, in her study "Disaster risk reduction activities as learning." In the study, she points a new dimension of disaster risk reduction learning and engagement activities after concluding that previous researchers on the subject matter focused on "curricula, instructional methods or program designs for disaster risk reduction activities rather than the learning process of those who are engaged in it." To this fact, the study goes further to highlight the importance of behavioral change by referencing Preston (2012, p. 5) to state that: "rehearsal is used to routinize and familiarize individuals and families with preordained rules of behavior," such that, behavioral changes for disaster preparedness include "learning through actual doing," as well as "learning from the consequences of the doing" (Kitagawa, 2021). Further from the recognition of engagements through structured learning curricula, additional studies buttress the point of learning by practice in a way that partaking in disaster preparedness activities increases preparedness efficacy, improves risk communication and opens up a discussion to clarify many uncertainties, especially in disaster simulations and exercises (Sun and Yamori, 2018). It is part of these reasons that many disaster preparedness and risk reduction activities are undertaken at local communities but are fronted by local organizations based on already established relationships required for clarifications and effective learning practices.

Therefore, what impact could COVID-19 have on local community organizations in the Tokyo Metropolitan Area in the wake of existing engagement approaches? To understand this, this study identifies the structures for disaster preparedness in Tokyo Metropolitan Area and the local governments, identifies some relevant voluntary and other local organizations that spearhead disaster preparedness for foreign residents in the local government areas and examines the impact of COVID-19 prevention on their engagement approaches through interview.

2. Local governments and efforts in disaster management

Contrary to the federal governance structure in places such as Germany, where disaster prevention and response highly rest on the state (Lim, 2016), Article 92 of the Japanese Constitution provides regulations concerning organizations and operation of local public entities and are established under the "local autonomy" law. The local autonomy law establishes and separates the procedures and activities of national and the prefectural/ municipal (herein referred to as "local government") authorities. The National Government is responsible for policies and affairs that require nationwide uniformity while local governments are responsible for the day-to-day administration of settlements from towns to cities. The administration of local governments encompasses the handling of wide-scale regional affairs, communication and coordination, education and environment and many others (Michihiro, 2010). The Basic Act on Disaster Management Act No. 223 of November 15, 1961, also reiterates the roles and responsibilities of local governments in disaster management. This makes it efficient for disaster communication between local authorities, residents and other local stakeholders because as pointed out by studies (ISDR/ITC/UNDP/ United Nations, 2010), local-level efforts in disaster management are a core component of risk reduction because local governments are able to:

- engage local communities as well as their citizens with disaster risk reduction activities that align with the concerns, vision and government priorities;
- strengthen institutional capacities and implement practical disaster risk reduction actions that may be peculiar to the status of the area; and
- devise and implement innovative tools, techniques and technologies for disaster risk reduction, capable of scaling up to nationwide coverage.

These notwithstanding, managing disasters and vulnerabilities has increasingly become challenging because of the interconnected process, procedures and guidelines involved in meeting the needs of stakeholders whilst reducing disaster intensities. The complexities of these activities have often resulted in shortfall measures that barely provide the needed mechanisms to reducing vulnerabilities. On the other hand, human nature and attitude to exercising recommended safety protocols have also been a major issue in the risk management frameworks (Radhakrishnan, 2020). Such a major attitude can be explained by the study by Weichselgartner (2001). In the study "Disaster Mitigation: The Concept of Vulnerability Revisited," emphasis is made on the need to rethink frameworks of disasters such that the way we think about disasters influences where we look for solutions. As echoed by other studies, making judgments about risk is not simple for individuals or any member of the public, because there should be an assessment nature of the hazards and its potential occurrence or impact, and match them with a range of alternative actions. However, the appraisal of these is highly dependent on the way a person judges the consequences of any particular action (Twigg, 2013). The judgment as alluded here has been extensively examined by Solberg *et al.* (2010) to include thorough psychological, perception and behavioral adjustments of individuals or groups of people. Hence concludes that many factors contribute to increased risk perception against disasters (Solberg *et al.*, 2010) and include cultural and other social segregation of fragile groups such as females, the aged, the young, ethnic minorities, low-income groups or status (Dosman *et al.*, 2001). Hence, trust, effective risk communication, education and training are key elements to reducing risk perception and collective disaster preparedness (APEC, 2012; Twigg, 2013).

The recognition of these intricacies of capacity enhancement, coupled with past experiences of disasters in Japan, is what necessitates conscious disaster management approaches at local communities through specially selected special days in the year dedicated to disaster preparedness activities, volunteerism and others. The weeks from August 30 to September 5 are declared "Disaster Management Week" with September 1 declared as "Disaster Prevention Day" while January 17 of every year marks "Disaster Response Volunteer Day," which is part of the "disaster response volunteer week." Furthermore, November 5 of each year is also declared as "Tsunami Preparedness Day." During these days, many community engagement activities are conducted including disaster drills simulation and exercises, fire prevention exercises, search and rescue practices and many others. At the forefront of these activities are the local organizations.

3. Relevance of public engagement practices and approach

Public engagement is a concept highly recognized and implemented in many fields and contexts because of its numerous advantages. The broader scope of its application has equally generated diverse opinions as to what qualifies or represents public engagement. Thus, the lack of consensus has created an illusion of a precise definition or identification. For instance, to some scholars, public engagement is well identified when examined from the perspective of information communication mechanisms that exist between authorities and the community. Definitions in this context encompass public communication, public consultation and public participation. The communication aspect is a top-down mechanism where information is sent from the source (usually from authorities) to the recipient (that is the community) whereas public consultation constitutes the opposite, where authorities seek or solicit information/feedback from the community. The hybrid of these two instances forms the participation component, where there is an exchange of information and ideas between authorities and the public. The application of these components gives the impression that the public is indeed engaged in a matter that concerns them (Rowe and Frewer, 2005). In other instances, the description of public engagements is prescribed against the backdrop of the type of decision to be made. Thus, the public is engaged depending on whether the decision is directive, consultative or collaborative. Per the definitions of the three decisions, consultative and collaborative in a decision-making process suggest the public is engaged (Government of Alberta, 2014). From other perspectives, public engagement is identified by the level of involvement of the public in the decision-making process (Knowlton, 2013) whilst considering the context or the purpose of the engagement, the structure of activities and the type of participants involved (Pytlikzillig and Tomkins, 2011). Despite these varied opinions, many public engagements seek to offer authorities the ability to empower populations to be able to make decisive decisions, by collaborating and consulting with them to be better informed (IAP2 International Federation, 2018).

In the process of public engagements, enormous knowledge is gained through discussions or from just passive participation. In either way, deliberations during public engagement fetch knowledge characterized by "informed (knowledgeable) opinions, attitudinal changes, rise in trust of institutions, and acceptance of resulting policies" (PytlikZillig *et al.*, 2018. p. 21). However, these outputs from deliberations in public engagement have been extensively associated with risk reduction and disaster preparedness. Okada and Matsuda (2006) in their analysis of the participatory process in disaster preparedness argue that disaster preparedness "can hardly be sustained unless appropriate knowledge is shared and transferred among the agents"; in that, people need to gain knowledge on existing hazards and risks, gain know-how on how to survive disasters and gain intrinsic local knowledge through knowledge sharing. Similarly, knowledge, attitude and trust are examined as vital tools for disaster preparedness (Setiawan *et al.*, 2020;

Uslaner, 2016). Therefore, to understand the success of public engagement activities, some studies rely on the number of participants (either active/passive), level of satisfaction, inclusiveness level and others (Knowlton, 2013). However, Pytlikzillig and Tomkins (2011) categorize the processes that lead to effective pubic engagement into “representation criteria,” “process criteria” and “outcome criteria” such that there is representation of the affected person, effective discussions and how the engagement improve existing situation. Hence, any impediment to such process could derail the effectiveness of the process, and may not achieve the intended purpose.

4. Situation of foreign residents in Tokyo Metropolitan Area

Population of foreign residents in the metropolitan area has increased over the years, and as shown in Figure 1, this growth equally comes with changing composition in terms of nationalities. Although Chinese nationals seem to be the dominant among this composition, other nationalities such as Vietnamese and Filipinos have gradually appreciated in numbers in recent years. The increasing number and the changing composition have already been researched to create challenges to risk information dissemination and accessibilities (Adu-Gyamfi and Shaw, 2021a). Furthermore, their agglomeration in certain communities in the metropolis is also a potential element to exposing their risk levels in event of an earthquake (Adu-Gyamfi and Shaw, 2021b). These and many have initiated calls for a broader engagement of foreign residents in risk preventions and information that consider language, lifestyles and other factors of vulnerabilities (Ikuyo, 2020).

In Japan, COVID-19 is classified as a designated infectious disease, hence authorities have the power and legal status to impose compulsory quarantine and other restrictions on infected persons. Therefore, a stray from a persistent engagement practice could have a huge impact on their livelihoods. Thus, of the total number of foreign resident workers in the country as of 2020, 23.3% are technical trainees (thus come to Japan for a skill-building program, sanctioned by companies involved), 20.8% work as “residents for work purpose”

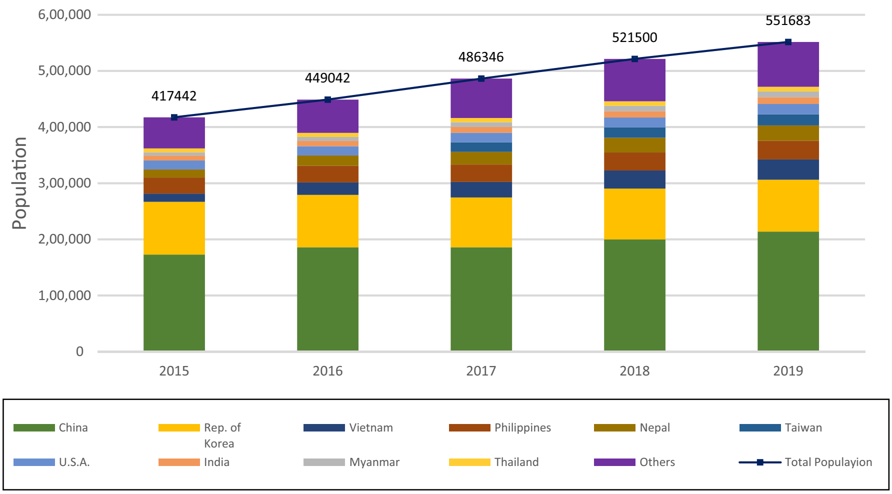


Figure 1. Population composition of foreign residents in Tokyo Metropolitan Area

Source: Authors, based on information from TMG (https://www.toukei.metro.tokyo.lg.jp/gaikoku/ga-index.htm) (thus those working in fields defined under a so-called professional and other technical fields) and 21% as "activities other than those permitted by the status of residence (thus comprising part-time jobs for international students and others) (Immigration Services Agency of Japan, 2019), implying that in the event where COVID-19 infection prevention and other protocols are misrepresented, misinterpreted or misjudged, the rippling consequences could be felt by individuals, families, organizations and communities as a whole.

5. Disaster preparedness engagement approaches for foreign residents in Tokyo Metropolitan Area

The approach to engaging foreign residents in the metropolitan area is found within the broad scope of the 2006 Multicultural Coexistence Initiative (*Tabunka Kyosei)* plan by the Ministry of Internal Affairs and Communication. By implementing such a plan at the local government level, the Tokyo Metropolitan Government (TMG) aims to foster intercultural cohesion by embracing diversity while building a city where all residents can participate and play active roles in the city's development, as well as ensuring their safety. Such an approach includes providing platforms and collaborating mechanisms for citizens, local organizations and other stakeholders. The organizations, together with local authorities, provide various information, including disaster preparedness to foreign residents in the respective areas (Tokyo Metropolitan Government, 2016). As shown in Figure 2, disaster preparedness information creation and dissemination are undertaken collaboratively by both in-person and non-contact mechanisms. Furthermore, as indicated by the Japanese Disaster Countermeasures Basic Act (Act No. 223, November 15, 1961) Article 7.2., ". . . residents of the area under local government are obligated to contribute toward the cause of disaster prevention by taking their own measures to prepare for disaster and by participating in voluntary disaster prevention groups, etc." (National Land Agency Japan, 1997). Hence, other local and volunteer entities engage foreign residents in disaster exercises, events, seminars and other activities to transmit disaster knowledge and other need learning experience to foreigners in the various local areas.

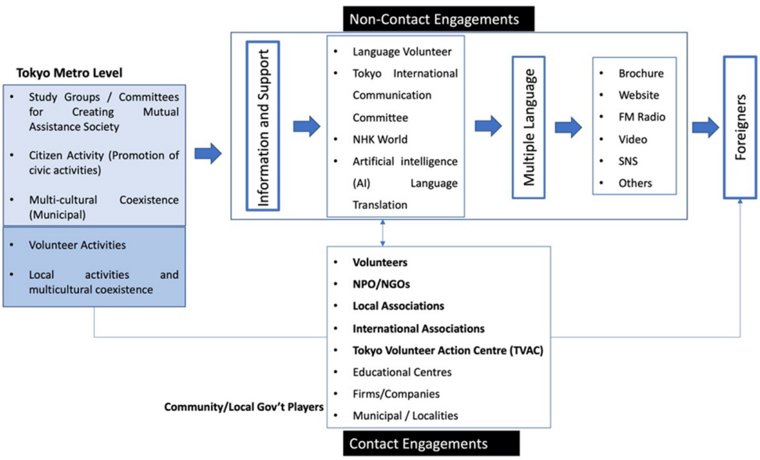


Figure 2. Engagement framework with foreign residents in Tokyo Metropolitan Area

6. Approach and methodology of this study

The study uses both quantitative and qualitative data collection and analysis intertwined between the review of public documents, reports and field interviews. By this, it identifies local organizations and examines their activities that enhance the disaster preparedness of foreign residents in the Tokyo Metropolitan Area. The activities are examined in the context of when there was no COVID-19 pandemic and the current state of the pandemic. A change in activities attributed to the COVID-19 pandemic is then extracted and explained through field surveys and interviews conducted between July and August 2021 with the relevant organization.

6.1 Identification of local organizations

The TMG recognizes 22 local international associations at the various local governments as part of its efforts to create a multicultural and mutual assistance society. Furthermore, a snowball approach is used to identify other organizations with similar characteristics. These groups offer consultation services to foreign residents, promote and teach easy Japanese language ("Yasashii Nihongo") and promote community cohesion through volunteering activities between foreign residents and Japanese nationals within local communities in conjunction with other agencies (Tsunagari, 2021). These activities are all essential to disaster preparedness for foreign residents in Japan (Ito and Tokarev, 2021). A literature review from secondary data sources was used to build a general overview of activities of the organizations before the COVID-19 pandemic but a few of the organizations were sampled for interviews to extract specific changes in activities.

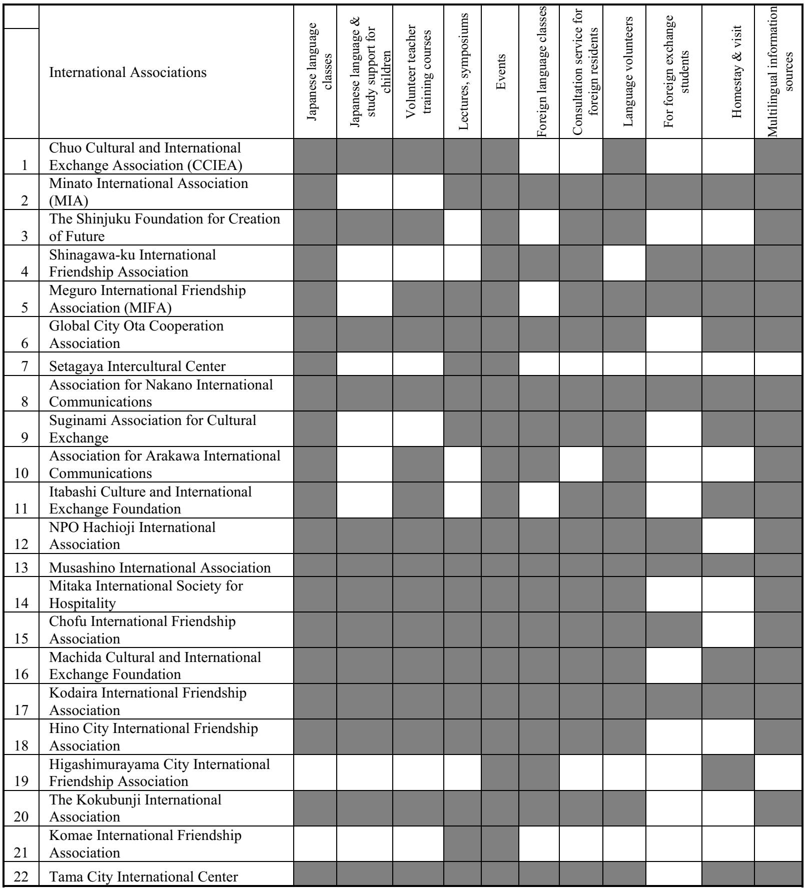
6.2 Detection of change in activities

From the general overview developed from Section 6.1 above, a matrix was developed with rows that show activities of three international associations, against columns that show the number of times those activities took place within the 2020/2021 fiscal year (from April 2020 to March 2021). They were then marked by representatives of the associations as to the number of days or hours for the activity. Further explanations of the activities are then sought through interviews. The results are analyzed qualitatively and quantitatively. For other selected organizations, the literature review provided a background for interviews concerning what may have changed because of the COVID-19 pandemic.

7. Results

7.1 Engagement of foreign residents by international associations

The activities of international associations in the Tokyo Metropolitan Area are mainly grouped into categories that are deemed essential to the city's vision of an inclusive and safe environment for all its residents. Realizing the importance of language abilities in disaster knowledge and preparedness, Japanese language lessons and cultural events dominate such activities. Figure 3 shows a list of the international associations and the type of engagement with foreign residents. The shaded boxes represent an engagement activity, while the blank shows none. About 90% of the associations conduct Japanese language lessons for adults, while 59% combine adults and children of foreign residents in language lessons. The remaining activities center on other educational activities to support foreign residents. The issue of Japanese language education can also be referenced as a means of breaking the language barrier which has consistently contributed to disaster prevention lapses among foreign residents in Japan (Sakurai and Adu-Gyamfi, 2020). "Yasashii Nihongo" or plain Japanese is one major learning



Source: Authors, based on information from TMG (https://www.toukei.metro.tokyo.lg.jp/gaikoku/ga-index.htm)

Figure 3. International associations and their engagements

approach adopted by TMG and is enhanced by international association as means of engaging foreign residents to able to read or understand basic Japanese associated with safety, disaster prevention, integration and mutual assistance. Thus, this concept uses simplified Japanese to explain, guide and implement disaster management activities (Ito and Tokarev, 2021). Before the COVID-19 pandemic, all these activities were conducted at the premises of the associations, city halls and local community centers, except for consultation services that could either be conducted in person or via email or telephone.

7.2 Foreign residents' engagement activities by volunteer organizations

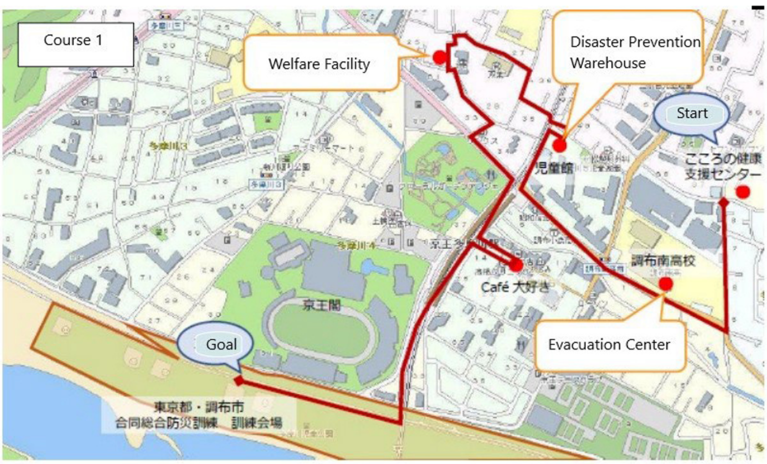
The study identified Tokyo Voluntary Action Center (TVAC) as a key player in this purpose because it was established to promote and support volunteer activities for which the center provides consulting services for volunteers and civic activities for individuals and groups, and also conducts human resource development events. It further provides hands-on experiences and training to groups and individuals in disaster prevention and management, either directly or through other affiliated groups (TVAC, 2021). One major activity identified to collectively involve foreign residents' preparedness against disasters in the Tokyo region is the "Disaster Walk." This is where various stakeholders made up of volunteers, NPOs, local governments and residents gather, walk through the selected areas to identify disaster-prone spots within the community and also familiarize themselves with important areas of the community such as fire hydrants spots, disaster shelter locations and stockpile warehouses in the community (TVAC, 2020). Thus, a community is selected every time for these events, and as shown in Figure 4 below, a route within the community is determined, members then walk along this route. This is vital for disaster preparedness, especially for foreign residents who may not be too familiar with certain parts of their communities and may not know other important elements of the community but can clarify through communication with other participants.

7.3 Foreign residents' engagement activities by the Bureau of Citizens and Cultural Affairs of the Tokyo Metropolitan Government

As part of enhancing disaster preparedness based on the Japanese Disaster Countermeasures Basic Act (Act No. 223, November 15, 1961), disaster prevention and preparedness drills are held each across all levels of government, agencies and other organizations (The World Bank, 2016). However, the Bureau of Citizens and Cultural Affairs of the TMG specifically organizes separate disaster drill events for foreign residents who per the language barrier or other circumstances are not able to attend general events. This event takes place each year, and Figure 5 shows an example of such an event's advertisement flyer.

7.4 Change in approaches to foreign residents' engagement

As seen in Figure 3, various methods are adopted to engage foreign residents in the metropolis. However, upon interviews with the selected international associations,



Source: Modified from TVAC Action Plan Promotion Council Report, 2017

Figure 4.
Community walk route for disaster preparedness

Source: Bureau of Citizens and Cultural Affairs Homepage (https://www.seikatubunka.metro.tokyo.lg.jp/chiiki_tabunka/tabunka/tabunkasuishin/0000000154.html)

Figure 5.
Flyer of disaster drill for foreign residents in Tokyo area

the core activities that have a direct association with disaster preparedness are Japanese learning course (under "Yasashii Nohongo" initiative), training of language volunteers to assist foreign residents in time of need, Japanese language teaching volunteers who further teach other foreigners "Yasashii Nihongo," and lectures or symposium on many topics including disaster preparedness and consultation services for everyday survival in Japan. As depicted in Figure 6, the outlined activities were undertaken within the 2020/2021 fiscal yearby the the Chuo Cultural and International Exchange Association (CCIEA), Meguro International Friendship Association (MIFA), and the Minato International Association (MIA). According to the interview conducted, the pre-COVID-19 pandemic era saw these associations undertake the following activities:

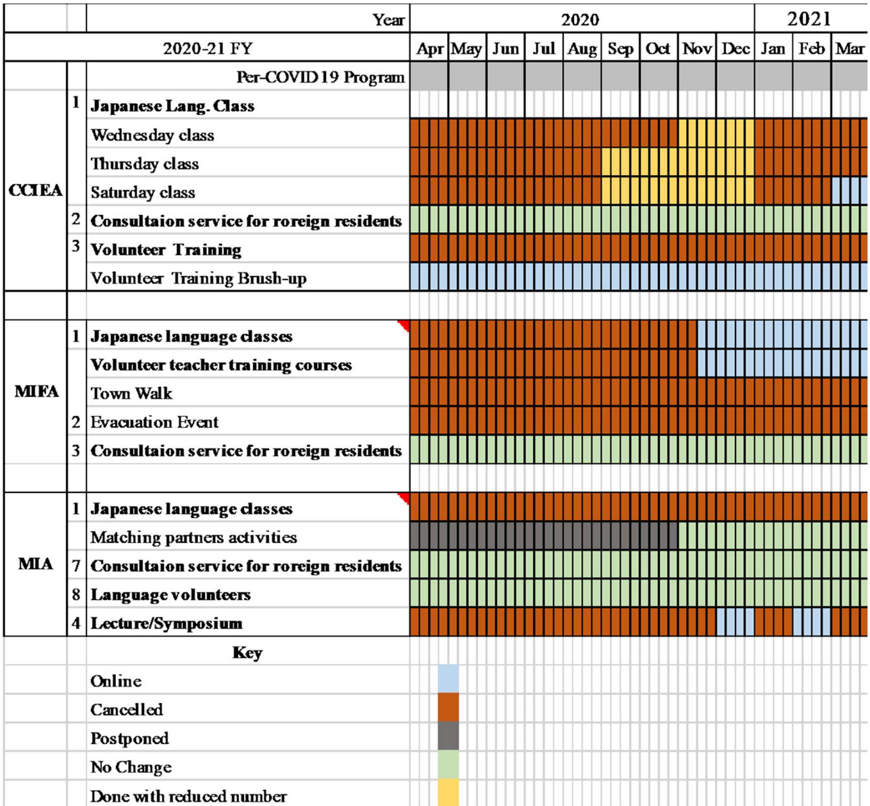


Figure 6.
Engagement activities of international association for foreign residents in tokyo metropolitan area

- Japanese language class: in person at the premises of the association and at the local city halls.
- Conduct consultations services: in person at the premises of the association or via online/telephone.
- Disaster preparedness and other communal events: in person at the premises of the association, at local city hall or communal areas.
- Train volunteers: in person at the premises of the association and at local city hall.

However, Figure 6 again shows how COVID-19 changed these engagement approaches because of pandemic restrictions of public gathering and SOEs declared in the metropolis. For CCIEA, which conducts three different "Yasashii Nihongo" classes that amount to roughly36 months in total, 25 of those months had their classes canceled, with ten conducted at a reduced number of participants. The situation is not different from the other two associations with MIFA having eight out of 12 months' worth of classes canceled. For the fiscal year under consideration, MIA could not conduct any classes such that, thus, all its 12 months of "Yasashii Nihongo" were scrapped. These notwithstanding, the assistance to foreign residents through consultations services remains unchanged. The reason for this situation was that for people that need assistance, much of the requests can be made via online or telephone with a limited in-person consultation. Furthermore, some in-person activities like training of volunteers were moved online with some Japanese classes also moved online via meeting platforms such as Zoom or Google meets.

In total, the associations conduct at least one to three classes each week, with each class lasting 1–3 h. Thus, an average of two classes per week, with 4 h average learning time. Hence, with 52 weeks in a fiscal year, each conducts at least a total of 104 Japanese language classes, accounting for 416 h of studies. Hence, the three associations have an average of 1,248 h of studies. However, in perspective, CCIEA lost 400 h of study out of 576. MIFA on the other hand lost 128 h of study out of 192. All of the 192 h of study were lost in the fiscal year according to MIA.

The loss in study and teaching hours caused by the pandemic is not peculiar to the international associations. By operation, the Disaster Walk event and the Disaster Drill Rehearsal program for foreign residents by the TVAC and the Bureau of Citizens and Cultural Affairs of the TMG, respectively, require a mass gathering of people and make use of public facilities and services. However, a ban on the use of public centers and COVID-19 spread prevention protocols meant that Disaster Walk could not take place in the fiscal year. Furthermore, Disaster Drill Rehearsal was equally canceled this year by its organizers, and many local governments also followed suit or conducted via online (NHK News, 2020). Meeting to discuss assistance programs for foreign residents in event of disasters in the Tokyo region, another event also organized by TVAC was also moved from in-person to online. Furthermore, the training of disaster volunteers was also moved online or canceled. For all events that were moved online, the following are the views expressed from the interviews:

- Japanese language classes are usually conducted by volunteers who are mainly retirees in the cities. Therefore, moving from in-person to online limited the number of volunteers because many are new to such online activities and faced many technological difficulties.
- In as much as there are reductions in volunteers, online presence also increases the audience of the classes because those who did not find time to time in-person were able to attend. Also, participants of the classes are usually foreign residents who reside in the respective cities. However, even though some move out of the city, they still join classes of their previous cities.
- There are always some technical issues with online events and classes as it sometimes becomes challenging to moderate, give the right experience or feel of a situation under description.

8. Discussion

Many scholars have given different methods and approaches to engaging the public in matters that concern them (Matthew C. Nisbet, 2015), but outputs or results of the engagement may differ even within one method or among methods of engagement (Pytlikzillig and Tomkins, 2011). This notwithstanding, what is important is the understanding of the approach that suits the purpose, the context of the application and the importance of undertaking such engagements (PytlikZillig *et al.*, 2018). These three instances align with this study in a way that past experiences with disasters in Japan have alluded to the fact that a reduction in impacts highly relies on the efforts of community spirit and the ability to understand various aspects of disaster preparedness. This situation becomes dire when it considers foreign residents and the role language plays in both preparedness and actions in event of disasters as explained in the earlier sections. Therefore, in line with the facts given by Kitagawa (2021), pre-COVID-19 pandemic engagement of foreign residents in the Tokyo Metropolitan Area can be classified by learning approaches that focus on in-person or person-to-person arrangements. A part of these in-person engagements yields an average of 1,248 h of study and interaction time. Other in-person approaches also offer disaster preparedness experiences associated with knowledge gained through active participation in a form of disaster drill rehearsals and disaster preparedness community walk. The contents within these two identified approaches share similar characteristics described as public dialogue and knowledge co-production (Matthew C. Nisbet, 2015). These arrangements of engagement suit the purpose of offering theoretical and practical experience to foreign residents whom many are novice to disaster preparedness protocols in Japan and the metropolis (Adu-Gyamfi and Shaw, 2021a).

However, an alteration to the approaches is taking place, this time in the context of preventing the spread and infection of COVID-19. As explained in Section 6.4, many of the initial in-person arrangements have moved online or canceled. As empirically given, online engagement has its negatives and positives (Smith and Gallicano, 2015). While some see the method of online engagement as a cost-effective approach (Government of Alberta, 2014), others argue the lack of emotions or commitment from the side of the user (Smith and Gallicano, 2015). However, in this study, the demerit of the online approach is the reduction in the number of volunteering as well as the difficulties of using some of the online tools by volunteers. In terms of the merits, the online approach has broadened participation numbers as explained earlier (although no figures were able to be secured from the organizations because of privacy concerns). Nevertheless, the major setback to the engagement approach is the cancelation of activities because of the pandemic. Thus, besides some accrued merits the changes may have brought, the effect of cancelation of activities is one thing with potential setback to the efforts of "kojo," "jijo," "gojo" and "kyojo." That is, in all of these four elements of disaster risk reduction, a certain level of Japanese language proficiency, disaster prevention protocol knowledge and risk awareness are imperative. These are the content of activities that have been canceled because of the COVID-19 pandemic.

Although this study did not examine the effectiveness of pre-COVID-19 pandemic engagement approaches and current changes attributed to the pandemic, many public engagement literatures acknowledge success to include the number of participants (Rowe and Frewer, 2005; PytlikZillig *et al.*, 2018), the "abilities of organizations to find ways to effectively and positively engage their stakeholders for meaningful partnerships" (Kang, 2014), the number of clicks on a website, access to websites and comments made online. Therefore, as organizations in this study have shown a glimpse of the above characteristics, there are indications of some level of effectiveness in their engagement approaches even amid a pandemic.

9. Conclusion

The study sought to understand the engagement approaches of local communities and organizations in assisting disaster preparedness of foreign residents in the Tokyo Metropolitan Area and to find out what impacts the COVID-19 prevention protocols have had on the approaches in the 2020/2021 fiscal year. It identifies organizations that collaborate with local governments and finds out that the pre-COVID-19 engagement approaches were highly dominated by in-person encounters in the form of Japanese language lessons under the context of "Yasashii Nihongo" at the premises of the involved organizations, local governments' city halls and other public places. Further in-person activities were undertaken in the form of community disaster walk and disaster drill rehearsals. Therefore, it is revealed that an average of 416 h are dedicated to "Yasashi Nihongo" per annum per organization, and per the sampled organizations, an average of 1,248 h are dedicated to Japanese lessons for foreign residents. However, to prevent the spread and infection of COVID-19, the study finds out that most of these in-person activities have been moved online. The change in approach from in-person to online has increased the number of participants who take "Yasashiee Nihongo" classes but has affected the number of volunteers who support the activities because of managerial challenges attributed to online engagement procedures.

The most setback to engagement activities attributed to the COVID-19 pandemic is the cancelation of many disaster drill exercises, community disaster walks, training of volunteers for foreign residents' assistance and many hours of "Yasashii Nihongo" lesson. To give a clue of the amount of impact, among three selected international organizations, CCIEA lost 400 h of study out of 576 while MIFA lost 128 h of study out of 192. All of the 192 h of study were lost in the fiscal year according to MIA. The effect of the cancelation of activities is a setback to the efforts of "kojo," "jijo," "gojo" and "kyojo," and in perspective, the working composition and visa status of many foreign residents are highly sensitive to sudden in schedules and operations such that, should there be any misrepresentation, misinterpretation of COVID-19 infection prevention and other protocols, authorities may quarantine, forced restrictions should there be infections and this will prevent access to work and other public places. The rippling consequences of such situation could be felt not only by the individuals but to families, organizations and communities as a whole. Therefore, to avoid such situations in the future, it will be essential for the TMG, local governments and associated organizations to develop their online procedures to a level of easy operation by all stakeholders or enhance other remote methods of public engagements to avoid cancelations or derailment of planned activities.

References

Adu-Gyamfi, B. and Shaw, R. (2021a), "Characterizing risk communication and awareness for sustainable society: the case of foreign residents in the Tokyo metropolitan area of Japan", *Sustainability (Sustainability)*, Vol. 13 No. 11, doi: 10.3390/su13115786.

Adu-Gyamfi, B. and Shaw, R. (2021b), "Utilizing population distribution patterns for disaster vulnerability assessment: case of foreign residents in the Tokyo metropolitan area of Japan", *International Journal of Environmental Research and Public Health*, Vol. 18 No. 8, doi: 10.3390/ijerph18084061.

APEC (2012), *The Role of Education for Natural Disasters*, Queenstown, Singapore, available at: www.criced.tsukuba.ac.jp/math/apec/ICME12/Lesson_Study_set/The_Role_of_Education_for_Natural_Disasters.pdf

Cabinet Office Japan (2018), "White paper on disaster management in Japan 2018", available at: www.bousai.go.jo/en/documentation/white_paper/index.html

Dosman, D.M., Adamowicz, W.L. and Hrudey, S.E. (2001), "Socioeconomic determinants of health-and food safety-related risk perceptions", *Risk Analysis*, Vol. 21 No. 2.

FEMA (2011), "A whole community approach to emergency management: principles, themes, and pathways for action, fdoc 104-008-1", available at: www.fema.gov/media-library-data/20130726-1823-25045-8164/pub_1_final.pdf%5Cn

Government of Alberta (2014), "Public input toolkit", available at: https://open.alberta.ca/dataset/5266e3ea-55a4-4856-be8b-8924dc48cdd1/resource/8aa5677f-b315-4a8a-8457-c4da3d6a3d94/download/ama-public-input-toolkit-sept2014.pdf

House, B. *et al.* (2017),. "Road investment strategy M25 junction 28 improvements stage 2 report on public consultation May 2017", available at: https://highwaysengland.citizenspace.com/he/m25-junction-28/results/m25-j28-consultation-report-v1.0.docx_final.pdf

IAP2 International Federation (2018), "IAP2's spectrum of public participation", available at: www.iap2.org/page/pillars%0Ahttps://cdn.ymaws.com/www.iap2.org/resource/resmgr/pillars/Spectrum_8.5x11_Print.pdf

Ikuyo, K. (2020), *Issues Faced by Foreigners in the Event of a disaster-Considering How Information Should Be Disseminated, Urban Policy Research*, Fukuoka City, Japan.

Immigration Services Agency of Japan (2019), "Initiatives to accept new foreign nationals and for the realization of society of harmonious coexistence", available at: www.moj.go.jp/nyuukokukanri/kouhou/nyuukokukanri01_00127.html

ISDR/ITC/UNDP/United Nations (2010), "Local governments and disaster risk reduction good practices and lessons learned a contribution to the "making cities resilient" campaign 2010".

Ito, H. and Tokarev, A. (2021), "From Yasashii Nihongo in non-disaster times towards a plurilingual language education approach: an outlook from the perspective of 'reasonable accommodation'", *F1000Research*, Vol. 10 No. May, pp. 1-16.

Joerin, J. and Shaw, R. (2011), "Mapping climate and disaster resilience in cities", *Community, Environment and Disaster Risk Management*, Vol. 6 No. 2011, pp. 47-61.

Kang, M. (2014), "Understanding public engagement: conceptualizing and measuring its influence on supportive behavioral intentions", *Journal of Public Relations Research*, Vol. 26 No. 5, pp. 399-416.

Kitagawa, K. (2016), "Disaster preparedness, adaptive politics and lifelong learning: a case of Japan", *International Journal of Lifelong Education*, Vol. 35 No. 6, pp. 629-647.

Kitagawa, K. (2021), "Disaster risk reduction activities as learning", *Natural Hazards*, Vol. 105 No. 3, pp. 3099-3118.

Knowlton, T.D. (2013), "Public engagement: building institutional capacity", available at: https://ucentralasia.org/Content/Downloads/IPPA_OP1_Public_Engagement_ENG.pdf

Lim, J.H. (2016), "The crisis management system in Germany", *Zeitschrift Der Koreanisch-Deutschen Gesellschaft Fuer Sozialwissenschaften*, Vol. 26 No. 1, p. 150.

Matthew C. Nisbet, E.M. (2015), "Public engagement research and major approaches", available at: http://weekly.cnbnews.com/news/article.html?no=124000

Michihiro, K. (2010), "Local government in Japan council of local authorities for international relations', 2016", available at: www.jlgc.org.uk/en/pdfs/LocalGovernmentInJapan2010.pdf

National Land Agency Japan (1997), "Disaster Countermeasures Basic Act – 1997".

NCCPE (2017), "How to develop a public engagement strategy", available at: www.publicengagement.ac.uk/sites/default/files/publication/developing_a_public_engagement_strategy.pdf

NHK News (2020), "Participation while staying at home online disaster prevention", available at: www3.nhk.or.jp/news/html/20200607/k10012461161000.html (accessed 3 August 2021).

Okada, N. and Matsuda, Y. (2006), "Community diagnosis for sustainable disaster preparedness", *Journal of Natural Disaster Science*, Vol. 28 No. 1, pp. 25-33.

Pytlikzillig, L.M. and Tomkins, A.J. (2011), "Public engagement for informing science and technology policy: what do We know, what do we need to know, and how will we get there?", *Review of Policy Research*, Vol. 28 No. 2, pp. 197-217.

PytlikZillig, L.M., *et al.* (2018),. "Deliberative public engagement with science: an empirical investigation", *SpringerBr*, Cham, Switzerland: Springer International Publishing.

Radhakrishnan, R. (2020), "I took Allah's name and stepped out":', (November)",

Rowe, G. and Frewer, L.J. (2005), "A typology of public engagement mechanisms", *Science Technology and Human Values*, Vol. 30 No. 2, pp. 251-290.

Sakurai, M. and Adu-Gyamfi, B. (2020), "Disaster-resilient communication ecosystem in an inclusive society – a case of foreigners in Japan", *International Journal of Disaster Risk Reduction*, Vol. 51

Setiawan, T.H., *et al.* (2020), "Development of knowledge and attitude measurement tools in disaster preparedness schools", *International Journal of Disaster Management*, Vol. 3 No. 1, pp. 53-62.

Shaw, R. (2012), "Overview of community based disaster risk reduction", *Community, Environment and Disaster Risk Management*, Vol. 10 No. 2012, pp. 3-17.

Shaw, R. and Takeuchi, Y. (2012), "East Japan earthquake and tsunami - key lessons for the education sector", p. 28, available at: http://unesdoc.unesco.org/images/0021/002161/216169e.pdf

Smith, B.G. and Gallicano, T.D. (2015), "Terms of engagement: analyzing public engagement with organizations through social media", *Computers in Human Behavior*, Vol. 53, pp. 82-90.

Solberg, C., Rossetto, T. and Joffe, H. (2010), "The social psychology of seismic hazard adjustment: re-evaluating the international literature", *Natural Hazards and Earth System Sciences*, Vol. 10 No. 8, pp. 1663-1677.

Sun, Y. and Yamori, K. (2018), "Risk management and technology: case studies of tsunami evacuation drills in Japan", *Sustainability (Sustainability,)*, Vol. 10 No. 9, pp. 1-14.

The Praxis Group (2012), "City of Saskatchewan – public engagement framework", available at: www.fortsask.ca/en/your-city-hall/resources/Documents/Report-Plans-Studies/Public-Engagement-Framework.pdf

The World Bank (2016), *Learning from Disaster Simulation Drills in Japan*. Washington, DC DC, United States, available at: https://reliefweb.int/sites/reliefweb.int/files/resources/011717drmhubtokyoLearningFromDisasterSimulationDrillsinJapan.pdf

Tokyo Metropolitan Government (2016), *Tokyo Guidelines for the Promotion of Intercultural Cohesion*, Tokyo, Japan, available at: www.seikatubunka.metro.tokyo.lg.jp/chiiki_tabunka/tabunka/tabunkasuishin/files/0000000755/shishin_all_eng.pdf

Tsunagari, T.M.F. (2021), "Creating a mutual assistance society", available at: www.tokyo-tsunagari.or.jp/english/joint/ (accessed 23 July 2021).

TVAC (2020), *Disaster Prevention Town Walk*, Tokyo, Japan.

TVAC (2021), "The Tokyo volunteer and citizen's activity center activity", available at: www.tvac.or.jp/tvac/welcome.html (accessed 23 July 2021).

Twigg, J. (2013), "Risk perception, public education and disaster risk management", *In Advances in Natural and Technological Hazards Research*, Springer Netherlands, pp. 171-182.

Uslaner, E.M. (2016), "Disasters, trust, and social cohesion", *Ritsumeikan Studies in Language and Culture*, Vol. 28 No. 1, pp. 183-191.

Weichselgartner, J. (2001), "Disaster mitigation: the concept of vulnerability revisited", *Disaster Prevention and Management: An International Journal*, Vol. 10 No. 2, pp. 85-94.

Welsh Government (2020), "Termination of pregnancy in Wales. Making permanent the temporary approval allowing home use of both pills for early medical abortion up to 9 weeks and 6 days gestation", available at: https://gov.wales/sites/default/files/consultations/2020-12/termination-of-pregnancy-arrangements-in-Wales_1.pdf

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Managing Compound Hazards: Impact of COVID-19 and Cases of Adaptive Governance during the 2020 Kumamoto Flood in Japan

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Abstract: Japan experienced natural hazards during the COVID-19 pandemic as some other countries did. Kumamoto and Kagoshima prefectures, including many other parts of southern Japan, experienced record-breaking heavy rain on 4th July 2020. While many countries were affected by compound hazards, some cases such as the Kumamoto flood did not cause a spike of the COVID-19 cases even after going through massive evacuation actions. This study aims to understand how COVID-19 made an impact on people's response actions, learn the challenges and problems during the response and recovery phases, and identify any innovative actions and efforts to overcome various restrictions and challenges through a questionnaire survey and interviews with the affected people. With an increase in the risk of compound hazards, it has become important to take a new, innovative, and non-traditional approach. Proper understanding and application of adaptive governance can make it possible to come up with a solution that can work directly on the complex challenges during disasters. This study identified that a spike of COVID-19 cases after the disaster could be avoided due to various preventive measures taken at the evacuation centers. It shows that it is possible to manage compound hazard risks with effective preparedness. Furthermore, during emergencies, public-private-partnership as well as collaboration among private organizations and local business networks are extremely important. These collaborations generate a new approach, mechanism and platform to tackle unprecedented challenges.

Keywords: COVID-19; flood; compound hazards; evacuation; volunteerism; adaptive governance

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1. Introduction

Compound hazards that combined natural hazards and the COVID-19 pandemic have had major impacts on the community and the environment, and consequently increased the virus spread [1,2]. In such multiple-hazard crises, governments and other responding agents are required to make complex, highly compromised, hierarchical decisions aimed to balance COVID-19 risks and protocols with disaster response and recovery operations. For example, the aggregation of evacuees into communal environments and increased demand on medical, economic, and infrastructural capacity associated with natural hazard impacts also increases COVID-19 exposure risks and vulnerabilities [3]. In India and Bangladesh, the number of COVID-19 cases drastically increased after the evacuation of more than 6.5 million, while the timely evacuation limited mortality as Cyclone Amphan affected both countries in May 2020 [4].

As in the case of Cyclone Amphan during COVID-19, two extreme events that are not related in origin but occur simultaneously or in succession are considered compound, multiple, or concurrent hazards [5]. They also have a characteristic of amplifying the impacts with the combined events and causing an extreme event when combined [6]. These compound hazards make the preparedness and response efforts more complex and challenging for both hazards. Protocols to combat the COVID-19 pandemic include the practice of social distancing and self-isolation; however, the emergency response such as evacuation actions requires expanded planning efforts for evacuation and sheltering options to limit possible virus exposure to evacuees and essential personnel [7].

Japan also experienced natural hazards during the COVID-19 pandemic. Kumamoto and Kagoshima prefectures of southern Japan experienced record-breaking heavy rain on July 4th, 2020. The rain caused devastating floods and landslides in many areas, which killed 83 people, and destroyed 15,335 buildings according to the Fire and Disaster Management Agency (FDMA; data available online at https://www.fdma.go.jp/disaster/info/items/200709_ooame26.pdf; accessed on 16 October, 2020). Sixty-five people died in Kumamoto prefecture alone. Kumamoto was the prefecture that was hit by a massive earthquake of 7.0 magnitude in 2016, which, according to an experienced volunteer who answered during an interview, prepared the prefecture in many aspects of disaster management compared to some other parts of Japan. However, the flood of July 2020 presented a number of new challenges because of the ongoing fight against the pandemic. The first severe COVID-19 positive patient was confirmed in Kumamoto Prefecture on February 21, 2020 (source: Kumamoto prefecture's website: https://www.city.kumamoto.jp/hpkiji/pub/Detail.aspx?c_id=5&id=36067; accessed on 16 October, 2020). Prior to the torrential rain disaster on July 4, 2020, no positive patients had been identified in the municipalities in the southern region of Kumamoto Prefecture, such as Hitoyoshi and Yatsushiro, which were affected by the torrential rain. Surveys through interviews of residents' actions immediately after the disaster revealed a low level of alertness to infectious diseases in the early stages of public shelters when people were evacuated to temples, public halls, and elementary school gymnasiums.

Although at the peak 2512 people were evacuated on July 12, it did not cause a drastic increase in the COVID-19 cases resulting from close contacts at evacuation centers [8]. As of July 14, only 49 infected persons had been reported in Kumamoto Prefecture, and no infections were confirmed in the southern region of the Prefecture, including the areas affected by the torrential rain (according to the data published on the website of Kumamoto prefecture; available at https://www.pref.kumamoto.jp/uploaded/attachment/112125.pdf; accessed on 16 October, 2020) Tashiro and Shaw [9] argued that this initial success could be related to the area's culture (such as non-touch greeting and sanitation practice since childhood), food habits, and advance healthcare system. However, Japan has been managing the response to COVID-19 pandemic under a "Special Measures Act to Counter New Types of Influenza" and not the "Disaster Countermeasure Basic Act" that covers natural disasters [10]. Although efforts were made to tackle this unique situation through emergency revision of the management guidelines, both the preparation for and the response to the July 2020 flood were eventually affected by the pandemic in many ways [11]. The evacuation centers in Kumamoto took various infection preventive measures against COVID-19 such as hand disinfection, body temperature checks, zoning of people with fever, etc. [12]. Social distancing was strictly maintained among the evacuees, which reduced the usual capacity of the designated evacuation centers to a great extent [11].

While many countries were affected by compound hazards and were forced to take extra measures and efforts to tackle different types of hazards at the same time, some cases such as the Kumamoto flood did not cause a spike of the COVID-19 cases, even after going through massive evacuation actions. The Cabinet Office and Fire and Disaster Management Agency (FDMA) in Japan jointly announced the general principle in evacuation that "people in dangerous places must be evacuated in the event of a disaster, and that this principle applies during the ongoing COVID-19 pandemic". Such an announcement and recommendation were made explicitly to prevent people from avoiding evacuation out of pandemic-related fears. At the same time, people were recommended and encouraged to evacuate to relatives' and acquaintances' places in addition to public shelters, or choose places that were not likely to be flooded, sleep in a car that was parked on a safe ground, and even move to the upper floor at home. This method is referred to as "dispersed evacuation" [13].

This study aims to understand how COVID-19 made an impact on people's response actions, learn the challenges and problems during the response and recovery phases, and identify any innovative actions and efforts to overcome various restrictions and challenges through a questionnaire survey and interviews with the affected people.

2. COVID-19 and Flood Response: The Need for Policy Integration of Compound Risks

Based on the experience of compound hazard management under the COVID-19 situation, some research has emphasized the need for new policies and approaches to compound hazard management. Kruczkiewicz et al. [14] stressed that the existing frameworks and guidelines do not apply to compound hazards, therefore, it is crucial to redesign the institutional regulations and structures including the funding mechanism to address compound risks. Ishiwatari et al. [10] argued that new approaches are needed to respond to floods more effectively under the pandemic and future compound hazards. The new approaches should include engaging local organizations and communities, strengthening risk communication with scientific knowledge, and coordinating multiple sectors. Yusuf et al. [7] also highlighted that the pandemic-related factors should be incorporated into emergency management policies and practices. Given the compound risks include not only flood but also wild-fires, earthquakes, drought, food security, and rising temperature, various stakeholders need to cooperate and address these multiple-risks, and prepare for the increase in compound pandemic–hazard threats. Simonovic et al. [15] discussed that the new approach has to focus more on disaster resilience, which can be a rather proactive and positive approach, as well as action-based resilience planning, rather than focusing on one hazard at a time. It is also vital to understand people's behavior to communicate what is resilience and how to prepare for and respond to these complicated events.

A literature search on the July 2020 Kumamoto flood was performed using CiNii (Citation Information by National Institute of Information) on September 15th with keywords "Disasters" and "COVID-19", and it generated 142 results. However, few results were yielded when the search was restricted to "the 2020 Kumamoto flood", which was the first natural hazard that Japan faced since the beginning of the COVID-19 pandemic. Only eight articles were generated by searching "the 2020 Kumamoto flood" and "COVID-19". Very few researches on the impact, linkage, and relation between the flood and COVID-19 in Japan were made.

Uchiyama and Danjo [16] addressed the effectiveness of a hazard map that showed the areas expected to be inundated by the Kumamoto flood. It proved that a hazard map could contribute specifically to developing an evacuation plan and drill. It also pointed out the difficulty of gaining volunteers under COVID-19 and that this delayed the recovery efforts in Kumamoto. Kawata [17] emphasized the need for transforming the current focus on disaster risk management and including the risk management from the cultural perspective, which considers human lives, culture, customs, and behaviors, not only the focus on the infrastructure and urban/city planning measures to prepare for a compound hazard risk. This is called "cultural disaster risk reduction". As such, a number of studies highlighted the need for transforming the current risk management approaches to new ones; however, the challenge is how the new approach should look and be developed. For that purpose, it is crucial to collect the case studies of responses to compound hazards and analyze them—what is missing and what went well, as well as how they could be widely applied. This study aims to showcase the local initiatives taken to overcome the challenges and continue the response and recovery efforts by local people without volunteers from outside of the affected prefecture, as well as the evacuation center management that avoided spreading the virus and keeping a safe environment for evacuees. These initiatives and approaches are considered "adaptive governance (AG)". At the end, this study highlights the importance of its concept as one of the potential approaches in a new strategy towards compound hazard response and recovery.

3. The Context of Frequent Flooding in Kumamoto and Attempts to Control Them

The Kuma River basin in Kumamoto prefecture is prone to flooding almost every time there is heavy rainfall in the region (Table 1). A class-A river (a first class river designated by the Ministry of Land, Infrastructure, Transportation and Tourism in Japan, indicating rivers that are especially important to the national economy) of 115-km length, Kuma River's course begins in the mountain range in Kyushu. After running through Hitoyoshi city, Kuma village, and Yatsushiro city of Kumamoto prefecture with a strong current, it discharges into the Yatsushiro Sea. Due to its location in South Japan, where heavy rain is very common, severe flooding episodes along the Kuma River have happened many times in recorded history, and the worst of these were in the mid-60s. When the area was affected by severe flooding three years in a row from 1963, the Construction Ministry (a predecessor of the Ministry of Land, Infrastructure, Transport and Tourism or MLIT in short) decided to construct a dam along the largest arm of the Kuma River as a flood control measure. The proposed dam, however, could have potentially affected the water flow, which eventually could have affected the tourism industry and agriculture. The central government, therefore, canceled the project in 2009 following resistance from the prefecture.

Three months after the July 2020 flood, an estimation compiled by the MLIT (available online: http://www.qsr.mlit.go.jp/yatusiro/site_files/file/bousai/gouukensho/20201006shiryou2.pdf; accessed on 5 August, 2021) was revealed, which showed that the canceled dam could have reduced the total area of inundation by 60.7%. The prefectural government has started to reconsider the proposed dam with design modifications following this revelation [18].

Table 1. Major floods along the Kuma River since the 1960s.

July 1965	Kuma river overflowed along almost its entire length because of extremely heavy rainfall, flooding almost two-thirds of Hitoyoshi city and breaking a part of the Hagiwara levee in Yatsushiro.
July 1982	The same areas were affected along the Kuma river after a record-breaking rainfall on July 24. Over 5000 houses were inundated and 47 houses were washed away.
August 2004	Heavy rainfall (664 mm in 4 days) brought by a typhoon towards the end of August caused the Kuma river to overflow along its mid-stream, forcing people of Hitoyoshi city and surrounding areas to evacuate.
September 2005	The mid-stream of the river overflowed following heavy rainfall caused by a typhoon. In total, 119 houses were inundated and over 750 families had to evacuate.
July 2006	Continuous heavy rainfall for 5 days raised the water level all along the Kuma river, which overflowed in places inundating 80 houses. Over 900 families in Hitoyoshi city, Yatsushiro city, Kuma village, and surrounding areas had to evacuate.
June 2008	Heavy rainfall caused the Kuma river to swell and overflow inundating 33 houses. In total, 1087 families in Hitoyoshi, Yatsushiro, and Ashikita town had to evacuate.
June 2011	The water level of Kuma river crossed the danger limit after heavy rainfall (566 mm over 4 days), forcing residents of Hitoyoshi city and surrounding areas to evacuate. At least 8 houses were inundated.

(Compiled by the authors based on the data from the website of MLIT's Yatsushiro River and National Highway Office: http://www.qsr.mlit.go.jp/yatusiro/river/kouzui/index.html; 17 September , 2021).

4. The Survey: Method and Key Findings

The online survey was conducted from March 2nd to March 11th in 2021, with the support of a survey company, to understand the impact of COVID-19 on the evacuation action taken by the residents and the change in volunteerism under the Kumamoto flood, and identify innovative response and recovery efforts taken by local communities to tackle the difficulties that they encountered during COVID-19 and the flood.

The questionnaire was constructed with a major focus on (1) the impacts of COVID-19 and the flood, (2) evacuation, and (3) volunteerism. The questionnaire was distributed and the respondents were identified by a survey company through their local networks. The constraint of this survey was that only people who have internet access were able to participate in this survey. A total of 276 samples were collected from the people in seven cities/villages of Kumamoto prefecture that were affected by the flood of July 2020. The data collected by the survey were compiled, digitized, analyzed using Microsoft Excel.

A breakdown of the target areas is presented in Table 2. The gender ratio of men and women was equal in this survey. The percentage of respondents in their 20s and 30s, 40s and 50s, and 60s and 70s were 53%, 36%, and 11%, respectively.

Table 2. Target areas of the survey.

Areas	No. of Answers	Percentage (%)
Kumamoto city	195	71
Yatsushiro city	43	16
Hitoyoshi city	14	5
Arao city	16	6
Tsunagi town	4	1.4
Sagara village	3	1
Kuma village	1	0.4

In addition to the questionnaire survey, interviews and hearings with some volunteers and local affected people were conducted from July to October in 2020 to understand the response practices made by the evacuation management committee and the volunteers. The interviews were also conducted with nonprofit organizations (NPOs) including Young Men's Christian Association (YMCA) and Peace Boat, who managed the evacuation centers at that time. Affected business owners who established a volunteer base, and local volunteers including students and business persons such as bankers were also interviewed. Through these interviews and hearings, innovative strategies and mechanisms on not spreading the virus at the evacuation centers, and ensuring human resources to assist the response and recovery efforts, were identified and introduced in this paper.

4.1. Impacts of COVID-19 and the Flood

Ninety-three percent of the respondents reported that the pandemic impacted their lives. The negative impacts on mental health, income, and social ties were relatively high (Figure 1).

In contrast to COVID-19, only 55% of the respondents answered that the flood impacted their lives. The largest impact was on mental health, and there was a wide gap between this and second largest impact, which was on income (Figure 1). Regardless of disaster type (pandemic or natural disaster), both COVID-19 and the flood had a serious influence on mental health in particular.

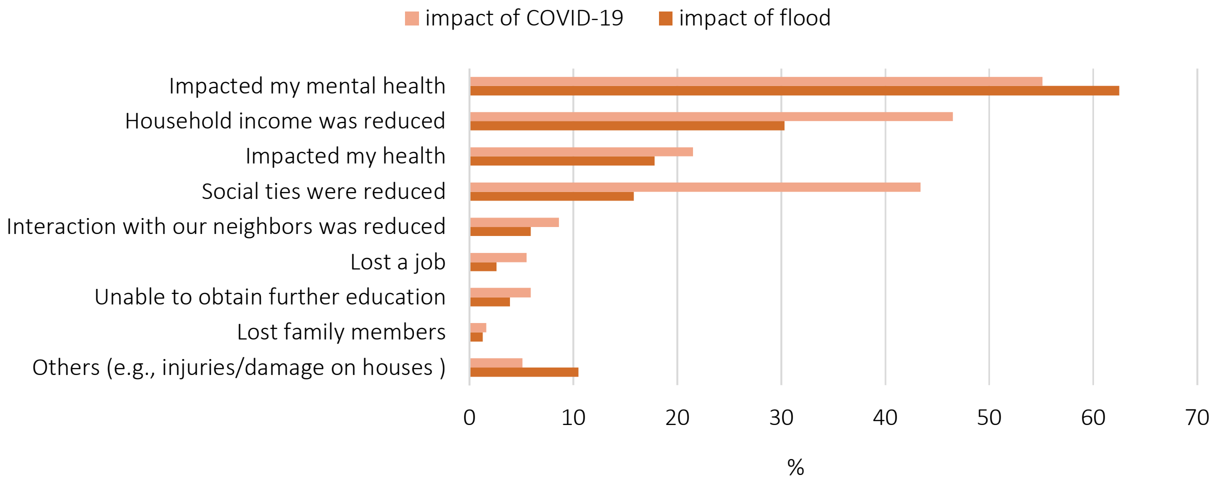

Figure 1. Impacts of COVID-19 and the flood.

4.2. Evacuation

Of the 276 respondents, 43 (16%) evacuated before the flood. Because heavy rains occurred from midnight to early morning, it may have been difficult to evacuate during that period of time. Among the respondents who evacuated, 80% answered that the risk of COVID-19 infection impacted their decision to evacuate. The greatest impact was that it took time to make the decision to evacuate.

Thirty percent of those who evacuated went to other places perceived to be safer instead of going to the designated evacuation center. Among them, 67% evacuated to a car and 25% evacuated to the home of a friend or someone they knew. These locations might have been chosen because of the evacuation situation at the time of the Kumamoto earthquake in 2016.

The respondents reported that "access to food and water" was their biggest concern when deciding whether to evacuate to an evacuation center (Figure 2). Their second most important concern was exposure to COVID-19 and "caring for children". However, the options included three COVID-19 related concerns—"COVID-19 infection", "cannot take enough preventive measures against COVID-19", and "cannot enforce sufficient social distance at the center". When these numbers are summed up, COVID-19 related concerns appear to be as important as "access to food and water". These concerns most likely stem from prior experience at an evacuation center or their understanding of the general conditions at the centers. Many people hold negative images of evacuation centers.

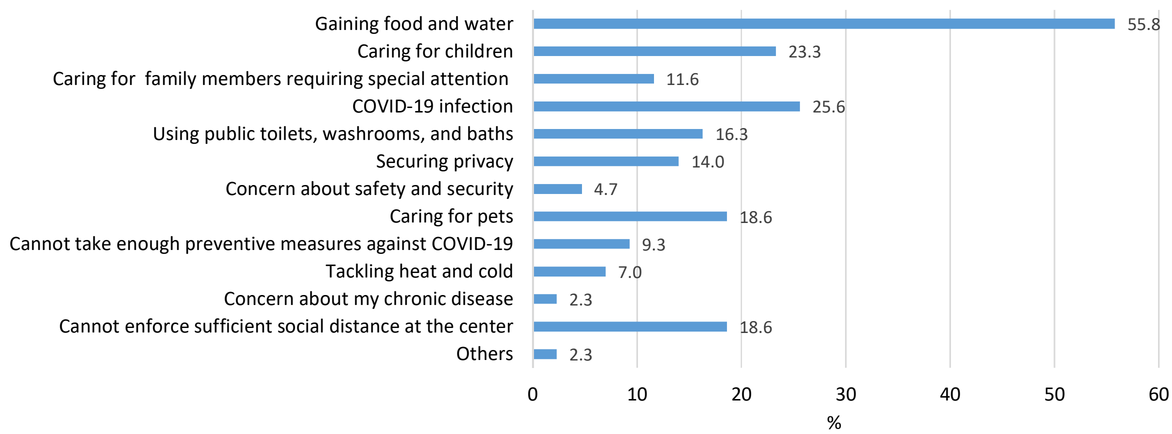

Figure 2. Concerns of the respondents at the time of evacuation.

The major problems encountered at the evacuation centers were “not enough food and other necessary items” (a major concern of evacuees regarding the evacuation centers before their evacuation) and “lack of privacy” (Figure 3). These problems were not related to COVID-19 but were rather common problems encountered at evacuation centers in Japan. In addition, around 20% of the respondents considered “using public toilets, washrooms, and baths” and “having to wear a mask all day” to be major problems. Only 12% considered having some social distancing at the evacuation centers to be a major problem. This finding indicates that the infection prevention measures, especially the practice of social distancing, had been taken at most of the evacuation centers; thus, people did not have to worry about it.

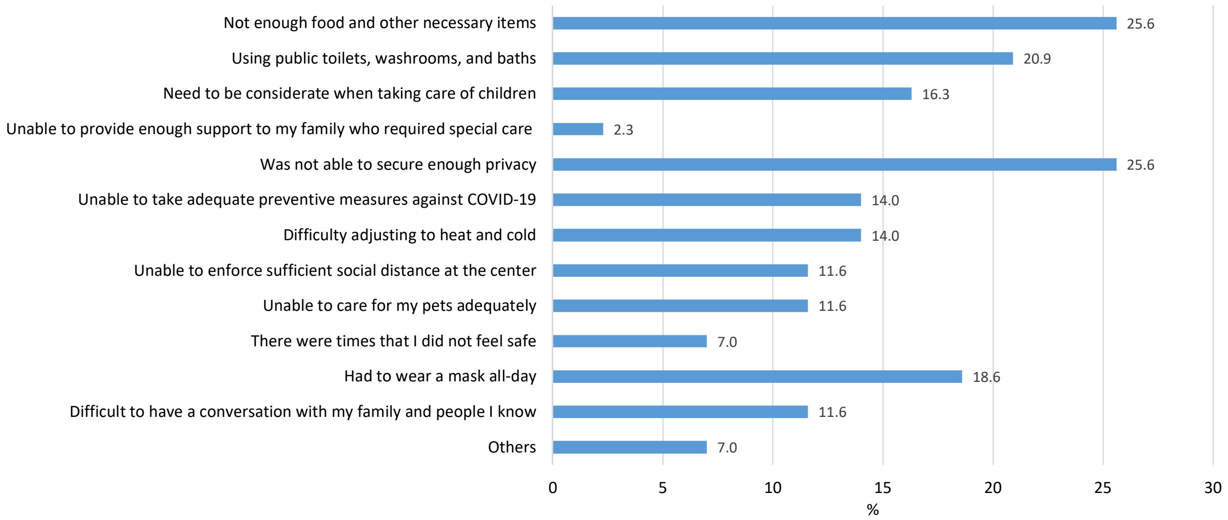

Figure 3. Major problems at the evacuation centers.

With regard to the reason why the respondents did not evacuate, 74% answered that they did not evacuate because they thought it was possible to secure their safety without evacuation. This indicates that 26% of those who did not evacuate considered not evacuating unsafe, but, for various reasons, still hesitated to evacuate. Improving or solving the problems at the evacuation centers may reduce this hesitation to evacuate and, thus, encourage more people to take necessary action as quickly as possible. Concerns about COVID-19 infection was the second most cited reason (9.4%) for not evacuating, which shows that the pandemic did affect people’s decision to evacuate. Only 1% thought that the evacuation itself was too much of a hassle.

4.3. Volunteerism

Among the 276 respondents, 11% (30) received support from volunteers. The small percentage was primarily due to the shortage of volunteers because of COVID-19-related restrictions. For instance, the volunteers were limited to Kumamoto prefecture to avoid spreading the virus (Website of Social Welfare Council https://www.saigaivc.com/202007/; accessed on 2 November, 2020).

Volunteers provided different types of support during and after the disaster (Figure 4). During the first week, the need was mostly to assist in distributing food, provide emergency items, and cleaning houses. After the first week, the need shifted to cleaning houses and providing urgent mental health support. After about a month, the focus was distributed to various types of support at the same time.

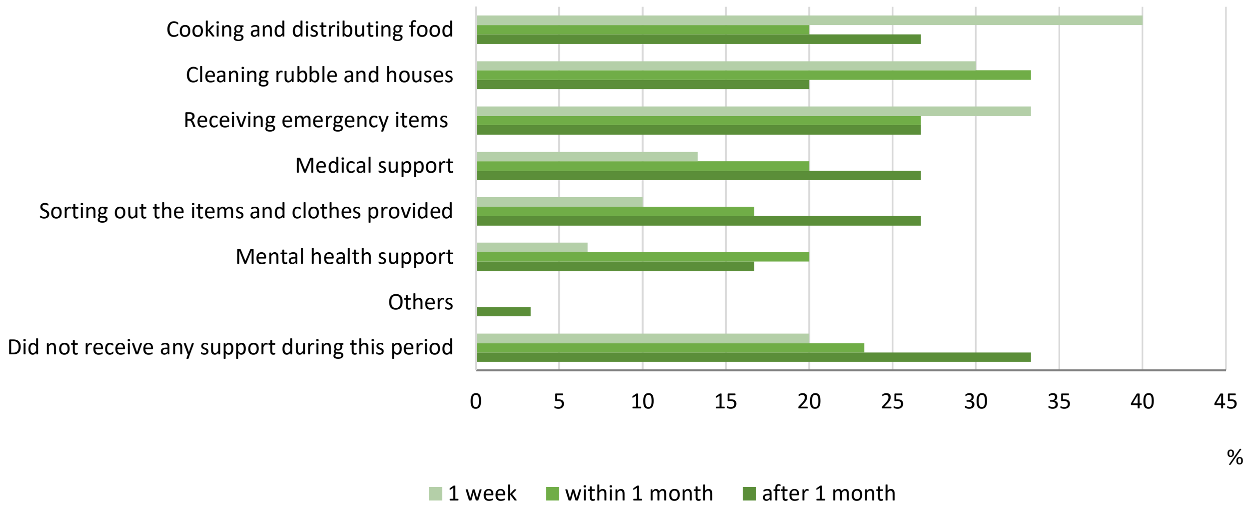

Figure 4. Support provided by volunteers.

Twenty-three percent of the respondents participated in volunteer activities. However, 77% (214) did not participate in any volunteer activities. The most cited reason for not participating was that they were "worried about COVID-19", which again shows a link between the pandemic and the shortage of volunteers. Fifteen percent did not participate in any volunteer activities because they were also affected by the flood.

5. Discussion with Case Studies of Evacuation and Volunteerism

The survey findings showed that COVID-19 and the flood had severe negative impact on mental health, income, and social ties. In addition, the compound disaster caused by COVID-19 and the floods had a significant influence on the areas of evacuation and volunteerism. This section further focuses on these two areas, introducing case studies collected mainly through interviews and observations at the time of the flood.

5.1. Evacuation

The survey findings revealed that COVID-19 had a major impact on the decision to evacuate. Respondents took more time to make the decision and many evacuated to places other than a designated facility. Thirty percent of the evacuees went to other places out of fear that they or their family members could be exposed to COVID-19.

Evacuation centers also had to take various preventive measures to prevent further spread of infection [13,19], following existing guidelines and the newly issued instructions from the government. The WHO [20] has pointed out that it is crucial that all preventive measures are carried out at evacuation centers, such as hand hygiene, wearing masks, social distancing, etc. It was also strongly recommended by the Japanese government to avoid the "three C's" that is, "closed spaces, crowded places, and close-contact settings", in the response to disasters in the midst of the pandemic [13]. The evacuation process and its management during COVID-19 and the flood were more complicated and challenging than the management of a single crisis. Some of these special measures taken in Kumamoto are described below.

5.1.1. Controlled Entrance and Setting Hand Sanitizers and Thermography

The entrance and exit at the evacuation centers were strictly controlled. The designated evacuation centers, which are usually gymnasiums of public schools, have more than one door, through which people can come and go according to their needs. However, in 2020, only one door was used for both the entrance and exit, so that only those who had permission could enter after a temperature check and hand sanitizing. A thermograph was placed in the reception area (Figure 5), as well as bottles of hand sanitizers.

Figure 5. Hand sanitizer and thermography at the registration tables.

While it is not uncommon to have hand sanitizers at evacuation centers, their placement at the entrance as well as at the common spaces, with monitoring by the management to ensure their proper use, was a measure taken for the first time. In most evacuation centers, hand sanitizers were placed in areas such as mobile phone charging stations (Figure 6) and library corners, apart from the reception at the entrance.

Figure 6. Hand sanitizers at mobile phone charging areas.

5.1.2. Social Distancing within the Evacuation Centers

In addition to setting preventive items, social distancing is also an effective measure for preventing viral transmission [21]. However, an evacuation center is often overcrowded and there is a high risk of COVID-19 infection [19,22]. To ensure adequate social distancing in order to prevent the spread of the virus, the evacuees were asked to stay only within a makeshift designated area marked by light materials such as cardboard or plastic floor mats. In some evacuation centers, the evacuees were dispersed throughout the facility, including available classrooms.

5.1.3. Dispersed Evacuation

The social distancing measures described above reduced the capacity of an evacuation center to nearly 30%. It was therefore crucial to designate more evacuation centers to accommodate the remaining evacuees, and, also, identify isolation facilities for infected individuals [23]. In order to increase the number of evacuation centers, non-traditional and non-designated evacuation centers such as hotels, other accommodation facilities, training facilities, and other potential places for evacuation were identified and people were encouraged to use them. This method is referred to as "dispersed evacuation" [13].

To implement "dispersed evacuation", municipalities became responsible for securing a sufficient number of designated evacuation centers in order to prevent secondary disasters.

Furthermore, it is also crucial that the evacuation of people to neighboring towns and cities through advanced agreements among neighboring municipalities is considered in case there is a shortage of evacuation centers. As of July 9, 2020, there were 403 evacuees from Kuma village in Kumamoto Prefecture, of whom it was only possible to accommodate 131 at four designated evacuation centers in Kuma village. Because the number of designated centers was insufficient, 272 evacuees were accommodated at the centers outside the village with support from neighboring municipalities [13]. Such efforts and initiatives to carry out evacuations to wider areas, beyond a traditional evacuation pattern that includes only designated centers in the evacuee's residential village, can expand the capacity to cope with large-scale disasters.

5.1.4. Some Issues That Call for More Attention

The preventive measures described above had some negative effects too. For instance, the measures limited exchanges among volunteers and evacuees, especially older adults who were assigned in small numbers to small classrooms. There was very limited opportunity for conversations or brief exchanges between evacuees and volunteers. The primary focus of all the extra measures was to prevent the spread of COVID-19 and keep the evacuees protected till they could be moved to individual temporary houses. This, in turn, may have forced some of the evacuees to keep their problems and discomfort to themselves, blocking the way for timely solutions.

Another important issue that came to light in the recent years was the environment at the evacuation centers. In June 2013, based on the experience of the Great East Japan Earthquake and Tsunami in 2011, Japan's Basic Act on Disaster Countermeasures was amended, and "Securing a good living environment at evacuation centers" was added. It became a responsibility of municipalities for securing a certain level of living environment at the centers, not only securing sufficient number of evacuation centers [24]. However, the issues such as "improvement of environment at evacuation centers" and "divergence of evacuation places" have been left unsolved until present [25]. Murosaki (2020) has pointed out that a general negative image about evacuation centers being "distant, unclean, and no-space" often causes the hesitation to evacuate. These issues have existed for many years, and the COVID-19 situation exposed them further. It is urgently required to review these issues and take actions to improve the situation [26].

5.2. Volunteerism

The survey findings indicated that a very limited number of people (11%) received assistance from volunteers. This finding can be explained by the severe shortage of volunteers due to travel restrictions during COVID-19. The first respondents during the initial weeks were individuals and organizations from within the prefecture [11]. The survey also showed that people did not participate in volunteer activities because they were "concerned about the possibility of COVID-19 infection" (57%). Only 15% answered that it was because they were also affected by floods.

Volunteer support is crucial in disaster response [25,27]. Volunteers provide a significant resource for emergency management [28]. There are several types of volunteers. Waldman et al. [29] categorized them into spontaneous volunteers and affiliated volunteers associated with emergency-related voluntary service organizations. Spontaneous volunteers participate in volunteer activities from outside the affected areas and do not have any formal training in disaster response [30]. If they do not have any formal training and are from the same community or neighboring areas, they are called "informal volunteers" who work outside of formal emergency and disaster management arrangements [30]. The communication and coordination among spontaneous or informal volunteers and affiliated volunteers are ineffective, and affiliated volunteers have concerns about the level of safety and liability associated with the work of spontaneous volunteers [28]. Whittaker et al. [28] indicated that those who work outside of systems tend to be viewed as nuisances or liabilities, and their efforts are often undervalued.

An "on-call civilian firefighter" is an example of a volunteer who has been trained. If they are from outside of the affected area, they are "expert volunteers" (e.g., health workers) or "formal or affiliated volunteers". Because disaster risks are increasing, it is expected that the need for and expectation of spontaneous volunteers will also increase [31]. It has become necessary to estimate the minimum manpower required for the cleaning and reconstruction work at each disaster-prone area, and create a sort of roadmap towards ensuring spontaneous volunteers from within the area itself [11].

During the Hanshin-Awaji earthquake disaster in Japan in 1995, a large number of volunteers came to the affected area to provide assistance; however, it was not possible to understand the needs of the affected people and effectively coordinate responses. Based on the lessons learned from these experiences, disaster volunteer centers (VCs) that aim to understand the needs of the affected people and coordinate the activities of volunteers are being established by the Social Welfare Association in the affected areas in collaboration with nonprofit organizations (NPOs) and volunteer organizations [32,33]. In addition, an NPO support center is often established to share tasks with VCs. While an NPO center collaborates with VCs, there is no clear division of work and responsibilities between VCs and NPO support centers [34]. In the case of Japan, most of the volunteers are usually spontaneous (coming from outside the affected areas/no formal training) or informal (coming from the same communities or neighboring areas/no formal training); however, they normally work after being registered as volunteers at disaster volunteer centers.

COVID-19 prevented volunteers from participating in support activities such as helping to clean houses and removing rubble, distributing necessary items, and cooking and distributing food [35] as these activities can interrupt social distancing [11]. In the case of the flood in Kumamoto in 2020, the affected people were allowed to accept support only from local volunteers (https://www.saigaivc.com/202007/); accessed on 2 November, 2020). The challenge of how to ensure the necessary support previously given by volunteers for relief and recovery assistance has emerged during the pandemic. Through interviews with affected people and volunteers, this study identified four new strategies for increasing volunteer support, in order to overcome this challenge.

5.2.1. Establishment of Volunteer Base by Business Owners

The recruitment of spontaneous volunteers was limited to those within Kumamoto prefecture, which did not ensure sufficient support personnel for the restoration of even ordinary homes. Therefore, restoration activities for hotels, stores, shops, etc., in the center of the city were aided not by volunteers dispatched from volunteer centers but by relatives, acquaintances, and those who in normal times had been business partners of the shop owners. Within Hitoyoshi City, private volunteer bases were set up, and stores performing restoration work began to appear and function as new hubs of activity. One man established a private volunteer group at his store's site. He manages a wholesale store selling a distilled drink from Kumamoto. This one-storied shop was flooded up to the ceiling. The center welcomed supporters from partner businesses, banks, etc., and placed containers at the site. The volunteers removed debris from disaster-struck stores, cleared away mud, and cleaned up.

At the volunteer base, drinks and ice were provided, a rest area was set up, and a large number of electric fans were operated to prevent heatstroke from working in the blazing sun. Due to the shortage of volunteers because of reasons described in the previous sections, there was very little expectation of volunteers being dispatched from official volunteer centers. Therefore, this private volunteer base was set up by a storeowner so that the efforts could be carried out by themselves. The volunteers were requested to wear masks, wash hand, use disinfections frequently, and measure their temperature in order to pay close attention to not spreading the virus. Moreover, the information of who worked where and with whom were saved in case someone became infected.

5.2.2. Recruiting Support Staff under "The Kuma Recovery Project"

To deal with the shortage of volunteers, a group of local organizations, in cooperation with the business community and other stakeholders, started a project called "The Kuma Recovery Project" a month after the 2020 flooding. Their objective was to connect three parties: (1) areas where volunteers were needed for cleaning work, (2) potential volunteers, who were mostly people who lost their business or jobs to the disaster, (3) contributors and fund providers.

There were certain criteria for people who could apply as volunteers. The potential volunteers could apply through the website, where a list of work sites and dates were posted. Based on the date and place of work, bus rides were provided. After a day's work, the volunteers were given a small amount of daily allowance from the fund created by the contributors. The website regularly posted updates of the recovery work performed under this project.

5.2.3. Involving Local Students in Relief Activities

The experience of the flood in 2020 during COVID-19 highlighted the challenge of volunteer service operations under the pandemic and the need for unconventional approaches to gain support for disaster relief. For instance, local students in Kumamoto prefecture were recruited to replace volunteers and were paid a minimum wage to provide the services normally provided by volunteers. Recruitment was carried out by the "Kumamoto Support Team," a private organization set up by volunteer members from Kumamoto Prefecture after the Great East Japan Earthquake and Tsunami in March 2011 to establish a support system to provide sustainable relief assistance. This organization became a general incorporated association in July 2020.

The organization used donations received from across Japan to manage volunteer activities by paying a daily allowance to university students who participated in the relief activities. Students who had lost income from part-time jobs due to COVID-19 were employed by the organization. In addition to a daily allowance, participating students were given meal coupons for use at restaurants and shops affected by the flood as part of a new initiative to help restaurants and shops affected by income loss. The initial budget was obtained through crowdfunding, with approximately JPY 20 million raised across Japan, exceeding the target amount of JPY 6 million. The total number of students who worked under this system had exceeded 1450 as of September 28, 2020 (Source: Kumamoto Support Team website: https://kumamoto-team.net/; accessed on 5 July, 2021).

5.2.4. Crowdfunding to Support Response and Recovery Efforts

At the time of the flood in July 2020, a private organization, "Student Disaster Volunteer Support Association" was established by university and NPO staff who had been carrying out support activities for the response and recovery effort after the Hanshin-Awaji earthquake in 1995. They started crowdfunding to gain support from student volunteers who were active within the prefectures affected by the flood because it was difficult to receive support from volunteers from outside the prefecture due to COVID-19.

These funds were mainly used to support the transportation and material costs of support activities and to cover activity expenses with the goal of promoting the proactive participation of student volunteers. However, the funds did not cover a daily allowance for the volunteers, which was different from the support given by the "Kumamoto Support Team". Applications for participation in the volunteer activities were accepted from universities with the requirement of forming a group of three or more people, not by an individual. Fundraising through crowdfunding targeted a maximum of JPY 200,000 per activity, and a total of JPY 5,000,000 for 25 projects. Within 2 months, a total of JPY

6,869,855 was raised, and the number of supporters reached 795. As of June 2021, there have been 24 completed or ongoing projects. Through this scheme, budgets were secured through crowdfunding to contribute directly to the response and recovery activities, and to enable groups to start the activities as soon as possible, not covering a daily allowance to individuals.

5.2.5. Revival of Traditional Systems

The first case of the establishment of a volunteer center by business owners succeeded in gaining volunteer support from their own business networks, without relying on the volunteers dispatched by official volunteer centers. This is considered a case of reactivation of a traditional mutual help system in communities. Other cases are new schemes to provide immediate necessary support to the affected people developed on the ground, which aided in overcoming the shortage of manpower and financial resources and fueled relief and recovery efforts.

Due to the difficulty of ensuring enough volunteers, two different types of mutual aid systems arose eventually: (1) flexible changes to disaster responses under the pandemic, not only to follow a traditional response, but rather to innovate and apply new mechanisms, exemplified by the cases implemented for operating evacuation sites and securing necessary support from the volunteers, and (2) the revival of traditional systems of mutual aid that existed for a long time in the region [35]. The experience of compound hazards in Kumamoto showcased not only new and innovative mechanisms and initiatives, but also the potential for the revival of traditional and the emergence of new mutual aid systems in the community that grew under the pressures associated with the non-arrival of volunteers on the mutual aid systems that existed before the disaster [36].

6. Conclusions

The findings from the interviews conducted for this study bring forth some important issues that can be crucial in the management of compound disasters of a similar nature in the future. The findings show, that while concerns for COVID-19 was the main reason behind the dilemma on whether to evacuate or not for most respondents (80% felt their decision to evacuate was impacted by COVID-19), once they were in the evacuation center, their major concerns were ensuring privacy, food, and necessary items (25.6% each). Only 14% of the respondents expressed concerns over protection against COVID-19. In other words, the findings show that COVID-19 infection was a much bigger concern before the evacuation than after, indicating some success of the measures taken at the evacuation centers. Some of these measures were instructed in the government guideline, but many were not—they came about as a response to certain issues that were created because of the complexity and uniqueness of the situation.

Similarly, concerns for COVID-19 affected the local residents' decision to volunteer at the early recovery stage. In this study, 77% of the respondents refrained from volunteering for this reason. Spontaneous volunteers from outside the prefecture could not access the affected areas because of travel restrictions in order to control COVID-19. This unprecedented situation severely affected the recovery process in the early weeks, and the strategies described in the previous section to overcome this serious issue show the importance of a participatory multi-stakeholder platform. These new strategies, including the reactivation of a traditional system to overcome the challenge of a shortage of volunteers can be explained as "adaptive governance (AG)". An AG approach is put forward as an alternative method of managing complex social–environmental problems including disasters [37]. AG calls for new governance systems that are "less rigid, less uniform, less prescriptive and less hierarchical, and promise a more innovative but effective way of dealing with complex environmental problems" [38]. One proposed innovation for more flexible and participatory methods of governance is through the multi-stakeholder platform, defined by Steins and Edwards [39] as: "Decision making bodies (voluntary or statutory) comprising different stakeholders who perceive the same resource management problem, realize their interdependence for solving it, and come together to agree on action strategies for solving the problem."

With an increase in the risk of compound hazards, it has become important to take a new, innovative, and non-traditional approach. Generalized guides are often not applicable to complex situations where several issues overlap. Proper understanding and application of AG can make it possible to come up with solutions that can work directly on the complex challenges during disasters.

This study eventually leads to the following conclusions:

- The COVID-19 infection was the second common concern at evacuation centers next to gaining enough food and water before people decided to evacuate. However, the most serious problem at the evacuation centers that people actually experienced was insufficient privacy, not COVID-19-related issues. This revealed a long-term problem and concern at evacuation centers. The general conditions at the evacuation centers need to be improved urgently to motivate people to take the necessary action at an emergency. At the same time, it is important to share the information on the safety and preventive measures taken at evacuation centers to eliminate "evacuation hesitation" for concerns related to infection.
- Income loss and mental health damage were most common impacts caused by COVID-19 and the flood. Therefore, financial support and assistance to recover from mental health damage are required at the recovery phase.
- Due to a lack of volunteers, it was difficult to access the necessary support normally provided by volunteers at the response and recovery phases. However, new mechanisms and initiatives to overcome this issue have evolved. The effectiveness of such innovative approaches should be further examined, and the experience should be shared widely.
- A spike of COVID-19 cases after the disaster could be avoided due to various preventive measures taken at the evacuation centers. It shows that it is possible to manage compound hazard risks with effective preparedness including timely communication and coordination.
- The preventive measures, however, restricted the interaction among the evacuees and management personnel to a great extent. This may have forced some evacuees to keep their problems and discomforts to themselves, which could lead to various serious issues including disaster-related deaths. Provision for alternative ways of communication and interaction need to be included in the evacuation centers considering this experience.
- During emergencies, public–private partnership as well as collaboration among private organizations and local business networks are extremely important. These collaborations generate a new approach, mechanism, and platform to tackle unprecedented challenges.

In recent years, the risk landscapes of the world have been increasingly complex. As stated earlier, governments and other responding agencies are having to make compromised decisions in the midst of multiple, overlapping emergencies, due to the lack of a consolidated roadmap towards the management of compound hazards. The changing climate has been adding to the complexity of these risks, making the need for a possible roadmap increasingly urgent. AG will be a key to managing compound hazards to overcome difficulties, especially during the recovery stage, that require a longer time and effort.

This study was conducted based on the experience and case studies in Kumamoto. The response and recovery efforts towards and from compound hazards, as well as their effectiveness, differ from country to country. For instance, the mass evacuation in some countries caused a rapid increase in COVID-19 cases. There should be innovative responses and recovery actions towards COVID-19 and natural hazards specific to each country. Furthermore, different challenges and problems need to be identified under different environments. Therefore, further studies, analysis, and comparison of the effectiveness of risk management on compound hazards need to be conducted based on the practices in different countries.

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Reference

1. Laws, J.C.; Strasiotto, L.S.; Daw, S.; Peden, A.E. When Natural Hazards Intersect with Public Health: A Preliminary Exploration of the Impact of Bushfires and the COVID-19 Pandemic and Australian Coastal Drowning Fatali-ties. *Int. J. Environ. Res. Public Health* **2021**, *18*, 5314.
2. Silva, V.; Eeri, M.; Paul, N. Potential impact of earthquakes during the 2020 COVID-19 pandemic. *Earthq. Spectra* **2020**, *37*, 73–94.
3. Quigley, M.C.; Attanayake, J.; King, A.; Prideaux, F. A multi-hazards earth science perspective on the COVID-19 pandemic: the potential for concurrent and cascading crises. *Environ. Syst. Decis.* **2020**, *40*, 199–215.
4. Shultz, J.M.; Fugate, C.; Galea, S. Cascading Risks of COVID-19 Resurgence during an Active 2020 Atlantic Hurricane Season. *J. Am. Med. Assoc.* **2020**, *324*, 935–936
5. Shi, P.; Lu, L.; Wang, J.; Chen, W. Disaster system: disaster cluster, disaster chain and disaster compound. *Nat. Disasters* **2014**, *23*, 1–12
6. Catto, J.L.; Dowdy, A. Understanding compound hazards from a weather system perspective. *Weather. Clim. Extrem.* **2021**, *32*, 100313.
7. Yusuf, J.E.; Hill, S.; Feo, E.L.; Whytlaw, J.L.; Richardson, T. The Compound Threat of COVID-19 and Hazards: Public Management and Policy Issues from a stakeholder Perspective. *Int. J. Policy Stud.* **2020**, *11*, 149–181.
8. Furukawa, T. After 3 Months from the Kumamoto Torrential Rains, Nishinihon Newspaper. Available online: https://b.hatena.ne.jp/entry/s/www.nishinippon.co.jp/item/n/650714/ (accessed on 3 October 2020) (In Japanese)
9. Tashiro, A.; Shaw, R. COVID-19 Pandemic Response in Japan: What is Behind the Initial Flattening of the Curve. *Sustainability* **2020**, *12*, 5250.
10. Ishiwatari, M. Multi-Hazard Approach to Compound/Cascading Disasters: Putting Experience in Developing Disaster Risk Reduction to Use in Pandemics, JIIA. 2 December 2020. Available online: https://www.researchgate.net/publication/347504777_Multi-hazard_Approach_to_CompoundCascading_Disasters_Putting_Experience_in_Developing_Disaster_Risk_Reduction_to_Use_in_Pandemics (accessed on 20 July, 2021)
11. Das, S.; Shaw, R.; Kanbara, S.; Abe, M.; Komino, T. Disaster during a Pandemic—Lessons from 2020 Flooding in South Japan, CWS Japan. 2020. Available online: https://cwsglobal.org/wp-content/uploads/2021/01/Disaster-During-a-Pandemic-1.6.2021.pdf (accessed on March 17, 2021)
12. Sawano, T.; Ito, N.; Ozaki, A.; Nishikawa, Y.; Nonaka, S.; Kobashi, Y.; Higuchi, A.; Tsubokura, M. Evacuation of residents in a natural disaster during the COVID-19 era. *Int. J. Med.* **2021**, *114*, 445–446.
13. Hashimoto, T.; Tashiro, K. Evacuation Plan under COVID-19 Crisis: Problem of the refuge in the complex disaster of COVID-19 and flood, *Kokushikan Disaster Risk Reduction/Emergency Rescue Comprehensive Research.* **2020**, *6*, 59–82. (In Japanese)
14. Kruczkiewicz, A.; Klopp, J.; Fisher, J.; Mason, S.; McClain, S.; Sheekh, N.M.; Moss, R.; Parks, R.M.; Braneon, C. Compound risks and complex emergencies require new approaches to preparedness. *Proc. Natl. Acad. Sci. USA* **2021**, *118*, e2106795118.
15. Simonovic, S.P.; Kundzewicz, Z.W.; Wright, N. Floods and the COVID-19 pandemic—A new double hazard problem. *WIRES Water* **2020**, *8*, e1509.
16. Uchiyama, S.; Danjo, T. *Characteristics of Flood Damage Due to Heavy Rain in Hitoyoshi City and Kuma Village, Watari District, Kumamoto Prefecture*, 1st ed.; Preliminary report; The National Research Institute for Earth Science and Disaster Resilience (NIED), Tsukuba, Japan. 2020. (In Japanese)

17. Kawata, Y. Response to social disaster through phase transition: Cases of COVID-19 and heavy rainfall disaster. *Res. Soc. Saf. Study* **2020**, *11*, 37–56. (In Japanese)
18. The Japan Times Kumamoto approves controversial dam after deadly July flooding 19 November 2020. Available online: https://www.japantimes.co.jp/news/2020/11/19/national/kumamoto-dam-approved/ (accessed on 5 December, 2020)
19. Nakai, H.; Itatani, T.; Horiike, R. Construction of an evacuee placement model for tsunami shelters considering physical distancing to prevent COVID-19 infection. *Prog. Disaster Sci.* **2021**, *11*, 100183
20. WHO Disaster Evacuation Shelters in the Context of COVID-19: Considerations for the Western Pacific Region. 2020. Available online: https://apps.who.int/iris/bitstream/handle/10665/336856/WPR-DSE-2020-033-eng.pdf?sequence=1&isAllowed=y (accessed on 1 July, 2021)
21. Prem, K.; Liu, Y.; Russell, T.W.; Kucharski, A.; Eggo, R.R.; Davies, N. The effect of control strategies to reduce social mixing on outcomes of the COVID-19 epidemic in Wuhan, China: a modelling study. *Lancet Public Health* **2020**, *5*, e261–e270.
22. CDC. CDC's Interim Guidance for General Population Disaster Shelters during the COVID-19 Pandemic. 2021. Available online: https://www.cdc.gov/coronavirus/2019-ncov/php/eh-practitioners/general-population-disaster-shelters.html (accessed on July 1, 2021)
23. Potutan, G.; Arakida, M. Evolving Disaster Response Practice during COVID-19 Pandemic. *Int. J. Environ. Res. Public Health* **2021**, *18*, 3137.
24. Noguchi, Y.; Kikuchi, S. Actual Conditions and Roles of Emergency Shelters in Rural Area: A case study on Nishihara Village after Kumamoto Earthquake. *J. Archit. Plan.* **2021**, *86*, 761–769.
25. Yamori, K. After Corona/Before Corona, Science of Fire-Fighting Disaster Risk Reduction, N0. 142. 2020. Available online: https://www.isad.or.jp/wp/wp-content/uploads/2020/12/no142_22p.pdf (accessed on 22 June, 2021). (In Japanese)
26. Brennan, M.A. Community Volunteers: The Front Line of disaster Response. *Int. J. Volunt. Adm.* **2005**, *23*, 52–56.
27. Haraoka, T.; Ojima, T.; Murata, C.; Hayasaka, S. Factors Influencing Collaborative Activities between Non-Professional Disaster Volunteers and Victims of Earthquake Disasters. *PLoS ONE* **2012**, *7*, e47203.
28. Whittaker, J.; McLennan Handmer, J. A review of informal volunteerism in emergencies and disasters: Definition, opportunities and challenges. *Int. J. Disaster Risk Reduct.* **2015**, *13*, 358–368.
29. Waldman, S.; Yumagulova, L.; Mackwani, Z.; Benson, C.; Stone, J.T. Canadian citizens volunteering in disasters: From emergence to networked governance. *J. Contingencies Crisis Manag.* **2018**, *26*, 394–402.
30. Sakurai, M. Who are Disaster Volunteers? The Tendency of Their Participation and Social Stratification, Policy Science. 26-1. Oct 2018. Available online: file:///E:/Downloads/ps_26_1_sakurai%20(1).pdf (accessed on 22 June, 2021).
31. Johansson, R.; Danielsson, E.; Kvarnlof, L.; Eriksson, K.; Karlsson, R. At the external boundary of a disaster response operation: The dynamics of volunteer inclusion. *J. Contingencies Crisis Manag.* **2018**, *26*, 519–529.
32. Daimon, H.; Atsumi, T. Rethinking relationships between survivors and volunteers following a disaster: A disaster volunteer center after the 2016 Kumamoto Earthquakes. *Disaster Symbiosis* **2018**, *2*, 25–32. Available online: https://ir.library.osaka-u.ac.jp/repo/ouka/all/68239/dak_002_025.pdf (accessed on July 25, 2021). (In Japanese)
33. Suga, M.; Fukutome, K.; Koshimura, S. Development of the Disaster Relief System Including Volunteer Activities: The Case Study of the Disaster Relief Volunteer Center in 7.13 Niigata Heavy Rain Disaster. *Regional Safety Association (7)2005,* 1-6.
34. Tsuchizaki, Y.; Ishii, D.; Hasegawa, M.; Kondo, S.; Iizuka, A.; Shibata, T. *Construction of Support System for Disaster Volunteer Activity: Activity Intention of NPO and the Role of the NPO Support Center*; Science of Regional Design by Utsunomiya University; Department of Regional Design, Utsunomiya, Japan: 2019; Volume 6, 63–74. (In Japanese)
35. JVOAD Disaster Response Guidelines for Volunteers and Non-Profit Organizations during the COVID-19 Pandemic. 2020. Available online: https://jvoad.jp/wp-content/uploads/2020/07/8cd983a87eb1934dda02d44a9e08b07a.pdf (accessed on 1 July, 2021).
36. Atsumi, T. Toward the Post-COVID-19 Society: as of April 2020. *Disaster Symbiosis* **2021**, *4*, 95–102. Available online: https://ir.library.osaka-u.ac.jp/repo/ouka/all/77180/dak_004_1_095.pdf (accessed on June 22, 2021). (In Japanese)
37. Djalante, R.; Holley, C.; ; Thomalla, F. Adaptive Governance and Managing Resilience to Natural Hazards. *Int. J. Disaster Risk Sci.* **2011**, *2*, 1–14.
38. Holley, C. Facilitating Monitoring, Subverting Self-Interest and Limiting Discretion: Learning from "New" Forms of Accountability in Practice. *Columbia J. Environ. Law* **2010**, *36*, 1211.
39. Steins, N.A.; Edwards, V.M. Platforms for collective action in multiple-use common-pool resources. *Agric. Hum. Values* **1999**, *16*, 241–255. https://doi.org/10.1023/a:1007591401621.