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Factors affecting flood-induced household vulnerability and health risks in Pakistan: The case of Khyber Pakhtunkhwa (KP) Province

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ABSTRACT

In recent years the adverse impacts of climate change on the natural environment and the multiple threats it poses to human health, especially in the Global South, have become increasingly evident and these are likely to increase in the near future, with more people likely to be risk. This study investigates households' vulnerability to public health risks in disaster-prone areas of Pakistan. It uses a dataset of 600 households, based on structured questionnaire with household heads from two severely flood-affected districts (Nowshera and Charsadda) in Khyber Pakhtunkhwa (KP). Household vulnerability to flooding and related health problems are assessed through a logistic regression model. The results reveal that respondents' socio-economic and demographic attributes, such as age, gender, education, income, the materials out of which their house is constructed, past experience of floods and social networks are the key factors influencing their flood vulnerability. Households' health vulnerability is affected by their access to information and health facilities, their sanitary arrangements, distance from the main health facility and previous damage to water supply and health facilities from the flood in 2010. The findings suggest the need to overcome households' flood and health vulnerability through capacity building, training and sustainable mitigation efforts. At the governmental level, a comprehensive and realistic stakeholder analysis is needed to ensure the active involvement of all stakeholders, to generate their commitment and support and to identify what actions are most needed. Any actions to minimize household health risks will require an integrated, multi-sector, approach which would increase efficiency through pooling resources and skills.

1. Introduction

Flood disasters are the most frequently occurring types of natural disasters [1], which occur as a result of rising sea levels and extreme precipitation, both of which are a consequence of climate change [2]. Many studies, conducted across the globe, have indicated that flood disasters can impact peoples' lives in many ways [3–6] and that the frequency and intensity of hydro-meteorological disasters in South Asian countries, including Pakistan, has increased in recent decades [7–9]. In Pakistan, the most catastrophic flood occurred in 2010, affecting more than 24 million people, damaging more than 2 million hectares of standing crops and resulting in over 10 billion USD of economic losses [10,11]. Due to climate change, these flood events are likely to occur more frequently, and their adverse impacts are likely to be more severe in the future. Keeping this in view, the Sendai Framework for Disaster Risk Reduction includes the objective of building resilience and fostering adaptive behavior to extreme weather-related events in order to reduce vulnerability to them.

The World Health Organization defines a healthy individuals an individual having a complete state of physical, mental and social

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wellbeing [12]. The common health impacts of flooding are complex [13], they include: causing acute stress [14], malaria and cholera [15], depression [16,17], anxiety, and posttraumatic stress disorder (PSTD), damage to infrastructure [18], the loss of the existing health system and healthcare delivery services [19] damage to water and sewage systems and disruption to existing public health care programs [20]. These impacts depend on nature and scale of the flood disasters, the speed at which people can return to their usual way of life, the presence of environmental contaminants, evacuation procedures and the assistance mobilized [21–23]. The assessment of vulnerability must take all these issues into consideration to estimate anticipated damages and their impact.

Public health organizations and disaster epidemiologists define the concept of risk and vulnerability in public health in different ways. The Society for Risk Analysis (SRA) identifies risk as the negative impacts of an uncertain event on human lives, property, and health. Risk can also be estimated on the basis of the probability, and likely frequency, of risks [24]. Public health has a dynamic relationship with the number and distribution of exposed people, the space that they occupy and the skills and resources available to satisfy their needs, while the 'vulnerable population' is defined as those people who are more prone to uncertain events (floods) with poor health status, lack of access to health care facilities [25], elderly, infants, and children [26,27].

When communities are affected by a disaster, protective behavior, fostered by the existence of strong family bonds and social connections play a crucial role in coping with its adverse impacts. However, disasters also disrupt the systems on which vulnerable people rely. For instance, older people, children, and disabled people may receive assistance from their family members, relatives or friends (access to food, water, electricity etc.) the supply of which may be interrupted by a flood disaster, making these groups more susceptible to the adverse impacts of the flood. Equally, people living in a flood prone areas where there is poor access to information about flood hazard risks are likely to be more vulnerable to the impacts of flooding [7]. Thus, individual vulnerability cannot be measured by one single indicator. A number of other factors must also be taken into consideration: including age [7], gender [28], family size [29], income [30], education [31], employment [7], building materials [32] and house ownership [33] etc. While there is ample literature available, both from the Global North and South [34–52] on different aspects of climate-induced disasters and their impacts on peoples' lives. There is a dearth of literature on households' vulnerability to flooding-induced health risks in disaster prone areas. Understanding such vulnerability could play an important role in strengthening individual or community responses to securing public health during and after flood disasters. This implies a need for policy makers to design sustainable preventive policies aimed at making communities more resilient and enhancing their adaptive capacity in order to minimize peoples' suffering.

Bearing in mind the aforementioned research gap, this study investigates household vulnerability to flooding-induced public health risks in Pakistan in two disaster prone districts of Khyber Pakhtunkhwa province. Specifically, the current study is designed to assess important attributes that could influence flood induced household vulnerability (socio-economic and demographic characteristics) and health risks (in terms of their access to health facilities and information, water sources, the type of latrines they possess, their access to safe drinking water and their distance from the nearest health facility).

2. Materials and methods

2.1. Study area and sampling strategy

This cross-sectional study was conducted in two severely flood affected districts, Charsadda and Nowshera, in Khyber Pakhtunkhwa (KP) Province in Pakistan. KP province was chosen purposively as its location and physical configuration makes its highly vulnerable to sudden and unexpected hydro meteorological disasters which require an immediate and integrated response [101]. KP Province is prone to flooding between July and September when the whole South Asian region experiences heavy monsoon rains. The province has experienced 22 major floods between 1950 and 2014, with the 2010 flood being the most disastrous [7]. The survey on which this analysis is based was conducted in February and March 2018 and covered 600 severely affected households (300 from each district) who participated in the survey (Fig. 1). The responses to the questions were recorded on structured questionnaires by the enumerators. This study adopted a multistage sampling technique to select respondents from severely affected districts. Firstly, we selected KP province due to its unusual geographical settings, high exposure, and vulnerability to climate induced disasters [7,8]. In the second stage of sampling strategy we purposively selected two of the districts in KP that were among the most severely affected districts by the 2010 flood (out of a total of 24 affected districts). In the third stage of sampling, we randomly selected three Union Councils (UC) from each district. In the fourth stage we selected two villages from each UC, based on the KP Provincial Disaster Management Authority's assessment report of the 2010 floods [102]. In the final stage of the sampling procedure, 50 households were randomly selected from each of the six selected villages, which were drawn from detailed lists of all households affected by the 2010 flood (which the administrative heads of each UC made available to us). Before initiation of the study, a proper orientation was given to the data enumerators about the study objectives, data collection tools (questionnaire) and methodology. Furthermore, the survey questionnaire was pretested in the field to give practical demonstration of infield practice of questions but also improve the quality of survey questionnaire by deleting (irrelevant) or adding (new information).

2.2. Household flood vulnerability

Wang and Roush [53] identify the importance of taking the likelihood and likely consequences of extreme weather-related disasters into account in order to arrive at a risk assessment. Cooper [54] recommends ranking disaster risks based on their likelihood (occurrence) and likely adverse effects (severity) to calculate a risk factor. In our research, we asked respondents to rank the incidence and severity of flood disasters using a Likert-scale (1 = low; 5 = high). The ranks of likelihood and consequences are summed in a risk matrix [55–58], which ranged from low (between 2 & 5) to high (between 6 &10) (see Fig. 2).

2.3. Analytical framework

We used logistic regression to analyze the determinants affecting respondent's perceptions of risk. The Logit model has been widely used in many studies [60]. Since our dependent variable is dichotomous, we can use Linear Probability Model (LPM), Logit or Probit models to estimate our parameters. One of the advantages of LPM is that the resulting coefficients are easy to interpret as compared to the Logit and Probit models. However, LPM has three major disadvantages: 1) the fitted probabilities can exceed the minimum bound of zero and maximum bound of 1, 2) partial effect of linear explanatory variable is constant at all levels and 3) residuals are heteroskedastic [61]. Logit and Probit families of models address the disadvantages of LPM and provide reliable estimates of probabilities in case of limited dependent variables. In simple settings, both Logit and Probit models provide similar results therefore we used logistic regression model for following the conventions in the field of disaster management. The general form of the logistic regression equation form is as follows;

$$\mathbf{logit}(\mathbf{Yi}) = \ln\left(\frac{\mathbf{p}}{1-\mathbf{p}}\right) = \boldsymbol{\alpha} + \boldsymbol{\beta}_1\mathbf{x}_1 + \boldsymbol{\beta}_2\mathbf{x}_2 \ldots\ldots \boldsymbol{\beta} \quad (1)$$

Where, Yi is a dichotomous variable, which represents the dependent

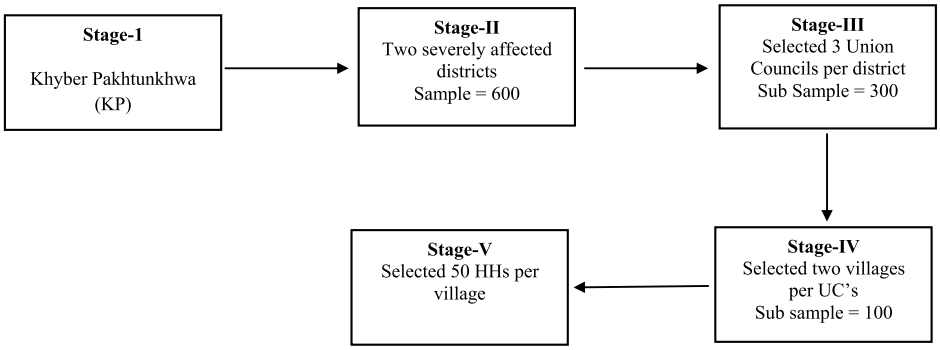

Fig. 1. Sampling framework of the study (Authors' own construction).

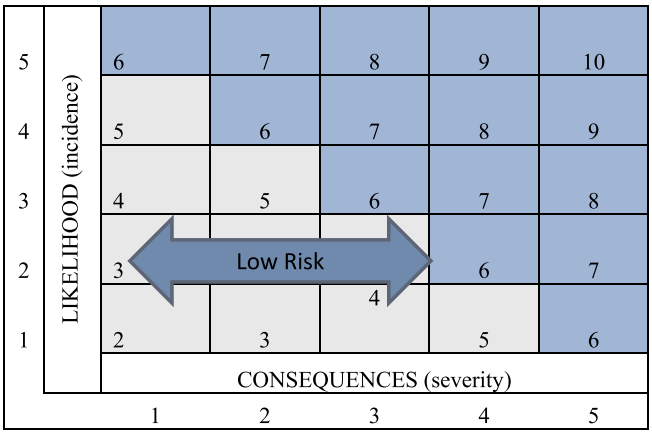

Fig. 2. Incidence-severity risk matrix (adapted from Ullah et al. [59]).

variable. In this study, Yi represents a household's vulnerability to flood incidents. Xi represents the explanatory variables (the households' socio-economic and demographic characteristics and their health vulnerability), α denotes the intercept and βi are the parameters to be estimated. The ln is the log of the odds ratio used to assess the probability density function. The parameters of the logistic regression were determined using the maximum likelihood method, as the ordinary least square method was not appropriate, due to the dichotomous nature of the dependent variable. The covariance of these explanatory variables was checked through correlation, after which a binary logistic regression model was applied to determine the factors affecting households' vulnerability to flood-induced health risks.

The socio-economic and demographic determinants used in the study were gender: (1 = male; and 0, otherwise), age (continuous), education level (continuous), family size (continuous), monthly income (continuous), multiple livelihood sources (1 = yes, otherwise 0), building materials (1 = reinforced cement concrete, otherwise 0), house ownership (1 = owner, otherwise 0), past flood experience (1 = yes, otherwise 0), and social networks (1 = affiliation, otherwise 0).

The household health vulnerability indicators used in this study are as follows: access to health facilities (1 = yes; and 0, otherwise), type of latrine (1 = septic tank; and 0, otherwise), access to health information (1 = yes; and 0, otherwise), distance from the nearest health facility (1 = >30 min; and 0, otherwise), health facility damaged by 2010 flood (1 = yes; and 0, otherwise), water sources (1 = piped water, and 0 otherwise), and water supply damaged by 2010 flood (1 = yes; and 0, otherwise).

3. Results and discussion

3.1. Descriptive statistics

The descriptive statistics of the selected variables used in the current research study are presented in Table 1. The majority of the sample respondents were male (81%) as the region is highly male dominated and, under strong local customs and traditions, females are not allowed to interact with male strangers [8]. The average respondent's age was 37.52, respondents had an average of 6.5 years of schooling and the

Table 1
Descriptive statistics of the selected variables.

S. No.	Variable	Description	Mean	SD
HH Flood vulnerability				
1	Risk of Flood	1, if the risk score is above 5 and 0, otherwise	0.81	0.39
HH Socio Economic and Demographic attributes				
2	Gender	1 = Male; and 0, otherwise	0.81	0.39
3	Age	HH age in years	37.52	15.85
4	Education	HH years of schooling	6.5	5.80
5	Family size	HH total number of family members in the household	6.43	3.13
6	Monthly income	HH monthly income in PKR	14991.95	12356.74
7	Multiple livelihood sources	1 = yes; and 0, otherwise	0.12	0.32
8	Building materials	1 = RCC; and 0, otherwise	0.32	0.33
9	Past flood experience	1 = yes and 0, otherwise	0.77	0.42
10	House ownership	1 = owner; and 0, otherwise	0.81	0.40
11	Social network	1 = affiliation; and 0, otherwise	0.74	0.44
HH Health Vulnerability				
12	Access to health facilities	1 = yes; and 0, otherwise	0.50	0.50
13	Type of latrine	1 = septic tank; and 0, otherwise	0.45	0.50
14	Access to health information	1 = yes; and 0, otherwise	0.44	0.50
15	Distance from the nearest health facility	1 = >30 min; and 0, otherwise	0.77	0.42
16	Health facility impacted by 2010 flood	1 = yes; and 0, otherwise	0.89	0.32
17	Water supply damaged by the 2010 flood	1 = yes; and 0, otherwise	0.69	0.42

Source: Derived from the survey results: 2018

average family size was 6.43. The average household monthly income was 14,991.95 PKR.[1] An average of 12% of the respondents had multiple livelihood sources, and 32% (on average) had houses constructed with reinforced materials (RCC). More than three quarters (77%) of respondents reported having had past flood experience: 81% owned their houses and 74% said that they had an affiliation with local community-based organizations (CBO). The study revealed that the households' health vulnerability varied significantly. Table 1 shows that 50% of household had access to health facilities such as Basic Health Units (BHU) and Rural Health Centers (RHC) and almost half (45%) had latrines connected to septic tanks. A similar proportion (44%) had access to health information provided by the government and NGOs and more than three quarters (77%) reported that they needed to travel more than half an hour to reach to local health facilities if they required emergency medical assistance. Eighty-nine percent of respondents reported that their local health facilities were impacted by the disastrous flood in 2010 and 69% that the flood impacted their water supply.

3.2. Factors affecting household vulnerability to flood-induced health risks

It is important to ensure that households in disaster prone areas of KP province are ready to deal with different kinds of natural disaster impacts, including floods and the health risks they can create. A prerequisite in achieving this aim is to conduct a vulnerability assessment of disaster prone communities in order to understand the local context, people's perceptions, knowledge, and ability and to participate in sustainable disaster risk management strategies [62]. To answer the study objective mentioned earlier in this paper, we discuss the study's results in terms of important attributes that could influence flood induced household vulnerability and health risks in Khyber Pakhtunkhwa province by using logistic regression model analysis as illustrated in Table 2.

3.2.1. Gender

Gender outlines the social worlds within which climate induced natural disasters occur [63]. The coefficient of gender illustrated in Table 2 has a negative but significant effect on flood vulnerability. The main reason behind this could be the fact that females take the primary role as care givers for children and older family members and this could lead them to compromise their own safety during climate induced natural disasters such as flood. Similarly, female household heads are more exposed to flood induced health threats as a result of patriarchy and the unequal distribution of opportunities that it gives rise to Ref. [64]. Some scholarly evidence [28] showed that gender has no significant effect on flood vulnerability, and that households in disaster prone areas are the most subject to higher aggregate risks.

3.2.2. Age

Age is another important determinant of vulnerability as the capacities of individuals to deal with disaster risk are strongly age-related and need to be improved [65]. Studies have shown that senior citizens and youth (i.e. those older than 65 years [66] and younger than 18 years [50]) are more susceptible to the health risks posed by natural disasters, such as floods as compared to the working age adults [67]. Our research confirms that age is significantly positively related to vulnerability to the health risks posed by floods (Table 2) and that household with older heads are more vulnerable than those with younger heads. Possible reasons could be their physical weakness due to physiologic changes [68], nutritional deficiencies [69], and weak immune systems (they need more assistance during and after flood disasters). These results are in agreement with the findings of other studies [33], which have found that aged people are hindered by their age and tend to be more (socially and economically) fragile and less able to respond swiftly to natural disasters.

Table 2
Factors affecting flood-induced household vulnerability and health risks.

S. No	Variable	Co-efficient	Standard error	P>|z|
1	Gender	−0.8872454	0.3934161	0.024
2	Age	0.0143651	0.0093921	0.023
3	Education	−0.0118487	0.0259412	0.013
4	Family size	0.0197763	0.0482254	0.682
5	Monthly income	−0.0000797	0.0000122	0.000
6	Multiple livelihood sources	−001.23913	00.729442	0.089
7	Building material	−03.681123	0.6941153	0.000
8	Past flood experience	0.6249782	0.3641008	0.086
9	House ownership	0.6348487	0.3356129	0.059
10	Social networks	−0.4812483	0.4158999	0.031
11	Access to health facilities	−0.7190964	0.3732116	0.054
12	Type of latrine	−0.5569267	0.3799025	0.003
13	Access to information	−01.488866	0.388643	0.000
14	Distance from the nearest health facility	−0.7447364	0.345852	0.031
15	Health facilities impacted by 2010 flood	02.953625	0.7462731	0.000
16	Damaged water supply infrastructure	0.8513204	0.3318805	0.010
	_constant	07.429326	1.108675	0.000

Number of obs = 600.
LR chi2(16) = 198.99.
Prob > chi2 = 0.0000.
Pseudo R2 = 0.3410.
Log likelihood = −192.24007.

3.2.3. Education

Education is also an important variable in determining social vulnerability as education enhances individual resilience in dealing with disaster risks [70]. Our study found the coefficient of education to have a significant negative effect on flood vulnerability. This might be because literate people have more individual capacity to access updated information that enables them to identify problems, appropriate solutions and have more skill and confidence in executing and communicating their ideas. By contrast those with a lower level of education are likely to be poorer, under (or un) employed, marginalized and lacking in self-confidence and capacity [71]. Low income groups are particularly at risk of natural disasters in that they are more likely to live in high risk areas and because the cost of repairing damage, reconstruction or relocation are likely to be proportionately greater for them [72]. Our study results support those of other studies [31,73], which show that people with a lower level of education (expressed with fewer years of formal schooling) are more vulnerable to natural or man-made disasters.

3.2.4. Family size

Family size is an essential attribute of social vulnerability and can effect, both positively and negatively a household's adaptive capacity to disaster risks [8]. In this study, the coefficient of family size has a significant positive relationship with the flood vulnerability. This might be because a large family might experience greater chances of disease transmission or and more competition over limited available resources, or they might have less savings to meet emergency needs during or after a disaster. Our findings about the family size coefficient are consistent with the results of other studies [74], which report that families with many individuals are more vulnerable to disaster risks due to their weak financial condition as a consequence of their lower spending power and reduced ability to purchase basics such as education, food, and health care.

3.2.5. Monthly income

In disaster prone communities, individual or household economic

[1] PKR is abbreviation for Pakistani Rupee, 1 PKR is approximately equal to 0.01 USD.

status plays a very important role in adaptive capacity in dealing with natural disasters [8]. The coefficient of household head monthly income, presented in Table 2, has a significant positive relationship with flood vulnerability. Households with a higher income level can more readily protect their families from the impacts of any disaster [75] and an increase in the monthly income of households significantly reduces vulnerability, flood-induced health risks and the severity of their consequences. Messner and Meyer [76] also identify that income levels not only affect individual households the resilience or vulnerability of a community as a whole. Our results are once again in agreement with the findings of other studies [7,33,71], which reported that higher level income groups respond more quickly and have more adaptation strategies at their disposal to mitigate against disaster risks.

3.2.6. Multiple livelihood sources

The coefficient of the household head having multiple sources of livelihoods (Table 2) has a significant negative relationship with flood vulnerability. Households with multiple livelihood sources are less vulnerable and more resilient to flood disaster as they have a diversified income, through different sources, that increase their financial resources and savings. These savings can be used to spend more on basic education, health, and food that reduce household vulnerability. It is evident from the literature that the type of economic activities also has a great influence on the socio-economic and demographic status of households by determining their net income. Employment is a critical indicator that influences household resilience/vulnerability to disaster impacts [16]. Our results are in line with other studies [77,78] that have found that households with multiple livelihoods or income sources are less vulnerable to the impacts of a flood disaster.

3.2.7. Building materials

The coefficient of building material, again illustrated in Table 2, also has a significant relationship with household flood vulnerability. A house constructed with flood resistant materials reinforced cemen concrete (RCC) is less vulnerable to flood disaster than one constructed with locally available materials (Mud). In our study, the majority of the sample respondents live within potential flood zones, as these are the cheapest places to acquire land. Financial constraints also mean that most of their houses are built with molded earth (Mud) which is less resistant to floods and highly vulnerable as they can easily be washed away by flood waters. Our results are in agreement with the findings of other studies [7,79,80], which found that houses built with molded earth (Mud) are more easily destroyed or damaged by a flood disaster.

3.2.8. Past flood experience

The personal experience of an individual is defined as a regency, the frequency of mortalities, and potential damages experienced as a result of the natural disaster [81] while the vicarious experience is felt in the context of social communication including hearing and reading about a disaster's multiple negative impacts that have affected friends, relatives and community members. An individual's previous personal experience of flood events can go a long way to influencing their flood vulnerability [82]. The coefficient of past flood experience shows that it has a significant positive effect on people's vulnerability. This might be explained by virtue of the fact that the majority of the sample respondents have experienced serious flood events in the recent past, some of which had devastating effects in terms of death tolls, property losses and damage to peoples' livelihoods. This can weaken them physically, financially, and psychologically and make them fearful of a repeat event as long as they continue to reside in a flood prone area. Our results are supported by other studies [7,83–88], which report that previous exposure to flood disasters increases the vulnerability of households to flood disasters.

3.2.9. House ownership

Home ownership is another important factor in determining household vulnerability to flood disasters. In our analysis, the coefficient of house ownership (Table 2) had a positive and significant effect on household vulnerability. Household heads who own their own houses are more vulnerable to the effects of flooding. The main reason for this might be that house owners take more responsibility for investing in flood resistant structures and adopting flood preventive measures to increase their resilience in response to flood disasters than households living in rented houses [7,89,90]. House ownership though reflect a stronger asset base however it tends to be associated with increased vulnerability as the owners find it hard to reallocate to safer areas compared to tenants who have flexible relocation plans when a disaster struck. These findings are in line with other studies [91,92], which found that house owners are more likely to invest in structural improvements to mitigate against future flood damage.

3.2.10. Social networks

Social networks are another crucial attribute that effect households' susceptibility to the impacts of natural disasters. These play a role in enhancing the capacity of an individual or group to cope with adverse flood impacts in the short run and to adapt to such effects in the longer term [93]. In this study, the coefficient of social networks has a negative and statistically significant effect on flood vulnerability. Disaster prone communities can increase their capacity to cope with emergencies by using social networks to bring together peoples' emotional, social, and economic resources. Such social capital builds on and enhances the norms, mutual trust, and can create a strong social network [94].

3.2.11. Access to health facilities

The coefficient of access to health facilities also shows a significant relationship with flood vulnerability, although this relationship is negatively associated. A large number of sampled respondents did not have access to health facilities at the local level as a result of the majority of the local health facilities having been damaged by the 2010 flood (and not subsequently repaired) or their houses being isolated. The sample respondents reported that very many health facilities, including BHUs and RHCs, were either not functional or were lacking the basic first aid facilities which would be required during an emergency situation. The findings of this study are in agreement with the results of Arbaiah et al. [95], who also found that the inaccessibility of health facilities increases vulnerability to the impacts of floods.

3.2.12. Type of latrine

The coefficient of the types of latrine also shows a significant and negative relationship with flood vulnerability. Human waste is a major potential source of public health risks following a flood disaster. The majority of respondents in our survey use pit latrines which can easily overflow after a flood creating outbreaks of contagious diseases. Further, many sample respondents reported that their pit latrines are in a poor state of repair, and a potential cause of cholera, which could put vulnerable groups such as women, children and elderly people more at risk in the event of a flood.

3.2.13. Access to information

We found that access to health information also had a significant negative relationship with flood vulnerability. This is logical since updated and timely information will allow households to safeguard themselves from the adverse impacts of a natural disaster, thereby reducing their vulnerability. These findings are in line with results of other studies [8] which found that households' access to information can provide social safety nets against disaster risks and reduce vulnerability in disaster prone communities.

3.2.14. Distance from the nearest health facility

We used the household head's walking time to the nearest primary health facilities as a further determinant of households' health vulnerability. This also showed a significant negative relationship with flood

vulnerability. Our survey showed that the majority of respondents live more than half an hour's walk away from the nearest health facility. Here we took the walking time of an able bodied person as the baseline, but children, pregnant women and elderly people would experience more barriers in terms of accessibility as it would take them longer to make such a journey and they would probably need to be accompanied by an able bodied (male) person. It goes without saying that greater access and more proximate health care services reduce the chances of infant and maternal mortality rates [96].

3.2.15. Health facilities affected by 2010 flood

In disaster prone communities, health facilities are public assets that play a crucial role in providing health services. One of the significant adverse impacts of flood disaster is the disruption of health services through direct damage to their structure or by indirectly affecting the accessibility and support systems (logistics, communications and/or power) [97,98]. In this study, the coefficient of health facilities damaged by the 2010 flood had a significant positive relationship with flood vulnerability. Communities that had more health facilities damaged by the flood were more vulnerable. In both districts, the majority of the respondents would rely on primary health care facilities (including BHUs, and RHCs) in the case of a disaster situation. However, the 2010 flood damaged many local primary health care services and impaired their functioning, increasing public health risks in any future inundation.

3.2.16. Damaged water supply infrastructure

Finally, access to an improved water source, one that is constructed in such a way as to prevent contamination by fecal matter, was also shown to have a significant positive relationship with flood vulnerability. Many respondents in our survey reported that their water supply infrastructure was damaged in the previous flood disaster and had not yet been fully repaired. This would increase a household's difficulties in accessing safe, clean drinking water, especially in any future flood incidents, which could disrupt the existing water supply arrangements. Many respondents reported that the majority of the government's water supply schemes (pipe lines) failed to provide clean drinking water and that proper monitoring systems were not in place to check the quality of the water supplied. These pipelines were often not adequately maintained and they were considered to pose a potentially significant threat to human health especially at times of flooding when drinking water could more easily be contaminated (by fecal matter) increasing households' health risks.

4. Conclusions and policy implications

This study used household-level field survey data collected from two severely affected districts of Khyber Pakhtunkhwa (Charsadda and Nowshera) to assess the factors that contribute to household vulnerability to the effects of floods and their associated health risks in Pakistan. The findings of this study strongly suggest that women, poor, and uneducated are most vulnerable to floods. Gender, poverty, and education are interrelated and they also have indirect effects on vulnerability through other socio-economic characteristics. For instance, poor households live in poorly constructed houses and they live in disaster-prone locations due to the low cost of land. The locations of these houses are usually far from basic health units and schools which directly affects their access to basic health and education. As a result, the relationship between poverty and vulnerability is amplified through indirect channels.

Education plays a crucial role in reducing flood-induced vulnerability and the health risks experienced by local people. Policymakers should invest in communication strategies to increase the risk perception of the population as higher perceived risk is strongly correlated with the likelihood of taking preventive measures. Previous research has shown that education is necessary for effective communication of flood risks as educated individuals are more likely to take safety precautions seriously [99]. The negative correlation between education vulnerability in the present study shows the importance of a well-educated community in designing disaster mitigating strategies. The educated population, especially women, are more likely to understand and implement the suggestions provided by the disaster management institutions. Moreover, in addition to improving access to education, the policy should also put extra effort into meeting the needs of the under-educated population as they are relatively more vulnerable than their educated counterparts. The uneducated women living in poor households are particularly vulnerable to disasters and they should be the priority of interventions aimed at reducing vulnerability. The results also show that access to adequate water and sanitation infrastructure reduces vulnerability to floods as contaminated water and inadequate disposal of fecal matter enable the fecal-oral route which leads to several health risks. The results indicate that piped water and septic tanks are relatively safer than other available options and investments in these two technologies can reduce the vulnerability of the households involved.

In Pakistan, and particularly in Khyber Pakhtunkhwa province, the community system is very strong which is why policies on reducing vulnerabilities should put a strong emphasis on social acceptability. Closely knitted communities provide a great opportunity for the policymakers to exploit potential spillover effects of even small to medium scale interventions. Individuals are more likely to respond to a strategy if someone in their close family has already done it [100]. It becomes quite evident from the analysis that training and capacity building of the service providers as well as community-based organizations is necessary to reduce the vulnerability to floods and that the interventions related to the reduction in vulnerability should follow a multi-sector approach. Proper mapping of the existing resources available to the public is required and it should be shared with every household so that everyone is aware of their options when the flood arrives. Moreover, a clear assignment of responsibilities is necessary so that the system starts operating the moment it faces the challenges associated with the flood in the future. Access to health centers is crucial, however, the capacity and efficiency of the health centers need significant improvement. Besides, as identified by this study, the potential causes of health risks in the study areas are complex and beyond the capacity of the health sector to resolve alone. So, any action to minimize household health risks will require an integrated multi-sector approach that would increase efficiency through multiple arms of policy. Finally, and perhaps most importantly, there is a need to build trust between the community and the government. When people trust the government, they tend to respond positively to the measures taken by the government [99]. No policy measure is likely to succeed in the presence of a trust deficit.

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Declaration of competing interest

The authors declare no conflict of interest.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ijdrr.2019.101341.

References

[1] K. Rattanakanlaya, et al., A survey of flood disaster preparedness among hospitals in the central region of Thailand, Australas. Emerg. Nurs. J. 19 (4) (2016) 191–197.
[2] I.P.O.C. Change, Climate Change 2007: Impacts, Adaptation and Vulnerability, Genebra, Suíça, 2001.
[3] D. Parker, C. Green, E. Penning-Rowsell, Swalecliffe Coast Protection Proposals–Evaluation of Potential Benefits, Flood Hazard Research Centre Middlesex Polytechnic, Enfield, 1983.
[4] C. Green, et al., The Health Effects of Flooding: a Survey at Uphill, Avon, Flood Hazard Research Centre, Middlesex Polytechnic, Enfield, 1985.
[5] S. Tapsell, et al., The Health Effects of the 1998 Easter Flooding in Banbury and Kidlington. Report to the Environment Agency, Thames Region, Flood Hazard Research Centre, Middlesex University, Enfield, 1999.
[6] C.A. Ohl, S. Tapsell, Flooding and human health: the dangers posed are not always obvious, BMJ Br. Med. J. (Clin. Res. Ed.) 321 (7270) (2000) 1167.
[7] A.A. Shah, et al., Flood hazards: household vulnerability and resilience in disaster-prone districts of Khyber Pakhtunkhwa province, Pakistan, Nat. Hazards (2018) 1–19.
[8] A.A. Shah, et al., Determinants of flood risk mitigation strategies at household level: a case of Khyber Pakhtunkhwa (KP) province, Pakistan, Nat. Hazards 88 (1) (2017) 415–430.
[9] Y. Hirabayashi, et al., Global flood risk under climate change, Nat. Clim. Chang. 3 (9) (2013) 816.
[10] A.A. Shah, et al., Schools' flood emergency preparedness in Khyber Pakhtunkhwa province, Pakistan, Int. J. Disaster Risk Sci. (2018) 1–14.
[11] A.A. Shah, et al., Current capacities, preparedness and needs of local institutions in dealing with disaster risk reduction in Khyber Pakhtunkhwa, Pakistan, Int. J. Disaster Risk Reduct. 34 (2019) 165–172.
[12] W.H. Organization, Manual of the international statistical classification of diseases, injuries, and causes, of death, Bull. World Health Organ. 1 (Suppl. 1) (1948).
[13] Y. Sawada, R. Bhattacharyay, T. Kotera, Aggregate Impacts of Natural and Man-Made Disasters: A Quantitative Comparison, The Research Institute for Economy, Trade, and Industry, 2011, p. 23. Discussion Paper Series 11-E.
[14] L.C. Waelde, et al., Symptoms of acute stress disorder and posttraumatic stress disorder following exposure to disastrous flooding, J. Trauma & Dissociation 2 (2) (2001) 37–52.
[15] R. Few, G. Pham, T. Bui, Living With Floods: Health Risks and Coping Strategies of the Urban Poor in Vietnam. Research Project Funded by British Academy (Committee for South East Asian Studies), Research Report, May, 2004.
[16] S.M. Tapsell, et al., Vulnerability to flooding: health and social dimensions, Philos. Trans. Royal Soc. Lond. A: Math. Phys. Eng. Sci. 360 (1796) (2002) 1511–1525.
[17] M. Reacher, et al., Health impacts of flooding in Lewes: a comparison of reported gastrointestinal and other illness and mental health in flooded and non-flooded households, Comm. Dis. Public Health 7 (1) (2004) 39–46.
[18] C. AbouZahr, T. Boerma, Health information systems: the foundations of public health, Bull. World Health Organ. 83 (2005) 578–583.
[19] G. Greenough, et al., The potential impacts of climate variability and change on health impacts of extreme weather events in the United States, Environ. Health Perspect. 109 (Suppl 2) (2001) 191.
[20] A.J. Linscott, Natural disasters—a microbe's paradise, Clin. Microbiol. Newsl. 29 (8) (2007) 57–62.
[21] S. Tapsell, S. Tunstall, The Mental Health Aspects of Floods: Evidence from England and Wales. Flood Hazards and Health: Responding to Present and Future Risks, Earthscan, London, 2006.
[22] F.O. Adeola, Flood Hazard Vulnerability: A Study of Tropical Storm Allison (TSA) Flood Impacts and Adaptation Modes in Louisiana, Citeseer, 2003.
[23] S. Galea, A. Nandi, D. Vlahov, The epidemiology of post-traumatic stress disorder after disasters, Epidemiol. Rev. 27 (1) (2005) 78–91.
[24] T. Aven, Risk assessment and risk management: review of recent advances on their foundation, Eur. J. Oper. Res. 253 (1) (2016) 1–13.
[25] A. Weathers, et al., Access to care for children of migratory agricultural workers: factors associated with unmet need for medical care, Pediatrics 113 (4) (2004) e276–e282.
[26] A.K. Gain, et al., An integrated approach of flood risk assessment in the eastern part of Dhaka City, Nat. Hazards 79 (3) (2015) 1499–1530.
[27] D. Phung, et al., The spatial distribution of vulnerability to the health impacts of flooding in the Mekong Delta, Vietnam, Int. J. Biometeorol. 60 (6) (2016) 857–865.
[28] E. Ligon, L. Schechter, Measuring vulnerability, Econ. J. 113 (486) (2003) C95–C102.
[29] K.W. Hlongwana, et al., Community knowledge, attitudes and practices (KAP) on malaria in Swaziland: a country earmarked for malaria elimination, Malar. J. 8 (1) (2009) 29.
[30] V. Cançado, et al., Flood risk assessment in an urban area: measuring hazard and vulnerability, in: 11th International Conference on Urban Drainage, 2008. Edinburgh, Scotland.
[31] R. Jha, et al., Vulnerability and Responses to Risk in Rural India, 2011.
[32] P.M. Graves, et al., Individual, household and environmental risk factors for malaria infection in Amhara, Oromia and SNNP regions of Ethiopia, Trans. R. Soc. Trop. Med. Hyg. 103 (12) (2009) 1211–1220.
[33] S.L. Cutter, C. Finch, Temporal and spatial changes in social vulnerability to natural hazards, Proc. Natl. Acad. Sci. 105 (7) (2008) 2301–2306.
[34] P. Duclos, et al., Flash flood disaster-nîmes, France, 1988, Eur. J. Epidemiol. 7 (4) (1991) 365–371.
[35] A. Yusof, et al., Floods in Bangladesh: pattern of illness and causes of death, J. Diarrhoeal Dis. Res. 1991 (1988) 310–314.
[36] Control, C.f.D. and Prevention, Morbidity surveillance following the midwest flood–Missouri, MMWR. Morb. Mortal. Wkl. Rep. 42 (41) (1993) 797, 1993.
[37] C. Staes, et al., Deaths due to flash floods in Puerto Rico, January 1992: implications for prevention, Int. J. Epidemiol. 23 (5) (1994) 968–975.
[38] S.F. Rashid, The urban poor in Dhaka City: their struggles and coping strategies during the floods of 1998, Disasters 24 (3) (2000) 240–253.
[39] C.L. Ogden, et al., Emergency health surveillance after severe flooding in Louisiana, 1995, Prehospital Disaster Med. 16 (3) (2001) 138–144.
[40] M.C. Maj, P.K. Maj, Health emergencies in large populations: the Orissa experience, Med. J. Armed Forces India 59 (4) (2003) 286–289.
[41] P.J. Baxter, The east coast Big Flood, 31 January–1 February 1953: a summary of the human disaster, Philos. Trans. Royal Soc. Lond. A: Math. Phys. Eng. Sci. 363 (1831) (2005) 1293–1312.
[42] E.K. Pradhan, et al., Risk of flood-related mortality in Nepal, Disasters 31 (1) (2007) 57–70.
[43] J. Schnitzler, et al., Survey on the population's needs and the public health response during floods in Germany 2002, J. Public Health Manag. Pract. 13 (5) (2007) 461–464.
[44] A. Biswas, et al., Unintentional injuries and parental violence against children during flood: a study in rural Bangladesh, Rural Remote Health 10 (1199) (2010) 1–12.
[45] T.H. Bich, et al., Impacts of flood on health: epidemiologic evidence from Hanoi, Vietnam, Glob. Health Action 4 (1) (2011) 6356.
[46] G. Berz, Flood disasters: lessons from the past—worries for the future, in: Proceedings of the Institution of Civil Engineers-Water and Maritime Engineering, Thomas Telford Ltd, 2000.
[47] B. Lastoria, et al., Socio-economic impacts of major floods in Italy from 1951 to 2003, Adv. Geosci. 7 (2006) 223–229, 2006.
[48] M. Llewellyn, Floods and tsunamis, Surg. Clin. 86 (3) (2006) 557–578.
[49] M. Ahern, et al., Global health impacts of floods: epidemiologic evidence, Epidemiol. Rev. 27 (1) (2005) 36–46.
[50] S.T. Ashley, W.S. Ashley, Flood fatalities in the United States, J. Appl. Meteorol. Climatol. 47 (3) (2008) 805–818.
[51] S. Jonkman, J. Vrijling, Loss of life due to floods, J. Flood Risk Manag. 1 (1) (2008) 43–56.
[52] G. FitzGerald, et al., Flood fatalities in contemporary Australia (1997–2008), Emerg. Med. Australasia (EMA) 22 (2) (2010) 180–186.
[53] J.X. Wang, M.L. Roush, What Every Engineer Should Know about Risk Engineering and Management, CRC Press, 2000.
[54] D.F. Cooper, Project Risk Management Guidelines: Managing Risk in Large Projects and Complex Procurements, John Wiley & Sons, Inc, 2005.
[55] W. Lu, A. Latif, R. Ullah, Simultaneous adoption of contract farming and off-farm diversification for managing agricultural risks: the case of flue-cured Virginia tobacco in Pakistan, Nat. Hazards 86 (3) (2017) 1347–1361.
[56] F. Zulfiqar, et al., Cotton production under risk: a simultaneous adoption of risk coping tools, Nat. Hazards 84 (2) (2016) 959–974.
[57] R. Ullah, et al., Managing catastrophic risks in agriculture: simultaneous adoption of diversification and precautionary savings, Int. J. Disaster Risk Reduct. 12 (2015) 268–277.
[58] R. Ullah, et al., Catastrophic risks management at farm: the use of diversification, precautionary savings and agricultural credit, Pak. J. Agric. Sci. 52 (4) (2015).
[59] R. Ullah, G.P. Shivakoti, G. Ali, Factors effecting farmers' risk attitude and risk perceptions: the case of Khyber Pakhtunkhwa, Pakistan, Int. J. Disaster Risk Reduct. 13 (2015) 151–157.
[60] E. Elahi, et al., Direct and indirect effects of wastewater use and herd environment on the occurrence of animal diseases and animal health in Pakistan, Environ. Sci. Pollut. Control Ser. 24 (7) (2017) 6819–6832.
[61] J.M. Wooldridge, Introductory Econometrics: A Modern Approach, Nelson Education, 2015.
[62] A. Steinführer, et al., Local Communities at Risk from Flooding: Social Vulnerability, Resilience and Recommendations for Flood Risk Management in Europe, ETH Zurich, 2009.
[63] E.P. Enarson, Gender and Natural Disasters, ILO, Geneva, 2000.
[64] U.N.D. Programme, U.N.D. Programme, Climate Shocks: Risk and Vulnerability in an Unequal World. Human Development Report 2007/2008: Fighting Climate Change: Human Solidarity in a Divided World, 2007, pp. 71–107.
[65] T. Cannon, Vulnerability analysis and disasters, Floods 1 (2000) 45–55.
[66] M.T. Thacker, et al., Overview of deaths associated with natural events, United States, 1979–2004, Disasters 32 (2) (2008) 303–315.
[67] C. Kuhlicke, et al., Perspectives on social capacity building for natural hazards: outlining an emerging field of research and practice in Europe, Environ. Sci. Policy 14 (7) (2011) 804–814.
[68] L. Zhang, et al., The clinical features and outcome of crush patients with acute kidney injury after the Wenchuan earthquake: differences between elderly and younger adults, Injury 43 (9) (2012) 1470–1475.
[69] F. Magkos, et al., Nutritional risk following a major disaster in a previously well-nourished population: who is vulnerable? Public Health 118 (2) (2004) 143–145.
[70] T.M.T. Tong, R. Shaw, Y. Takeuchi, Climate disaster resilience of the education sector in Thua Thien Hue province, Central Vietnam, Nat. Hazards 63 (2) (2012) 685–709.
[71] S. Rufat, et al., Social vulnerability to floods: review of case studies and implications for measurement, Int. J. Disaster Risk Reduct. 14 (2015) 470–486.

[72] M. Masozera, M. Bailey, C. Kerchner, Distribution of impacts of natural disasters across income groups: a case study of New Orleans, Ecol. Econ. 63 (2–3) (2007) 299–306.
[73] M. Jukes, S. Simmons, D. Bundy, Education and vulnerability: the role of schools in protecting young women and girls from HIV in southern Africa, AIDS 22 (2008) S41–S56.
[74] T.D. Kirsch, et al., Impact of the 2010 Pakistan floods on rural and urban populations at six months, PLoS Curr. 4 (2012).
[75] C. Green, A. Van der Veen, E. Wierstra, Vulnerability refined: analyzing full flood impacts, in: E. Penning-Rowsell, M. Fordham (Eds.), Floods across Europe–Flood Hazard Assessment, Modeling and Management, Middlesex University Press, London, United Kingdom, 1994.
[76] F. Messner, V. Meyer, Flood damage, vulnerability and risk perception–challenges for flood damage research, in: Flood Risk Management: Hazards, Vulnerability and Mitigation Measures, Springer, 2006, pp. 149–167.
[77] S. Qasim, et al., Risk perception of the people in the flood prone Khyber Pukhthunkhwa province of Pakistan, Int. J. Disaster Risk Reduct. 14 (2015) 373–378.
[78] S. Qasim, et al., Community resilience to flood hazards in Khyber Pukhthunkhwa province of Pakistan, Int. J. Disaster Risk Reduct. 18 (2016) 100–106.
[79] E.L. Bohensky, A.M. Leitch, Framing the flood: a media analysis of themes of resilience in the 2011 Brisbane flood, Reg. Environ. Chang. 14 (2) (2014) 475–488.
[80] L. Bosher, et al., Attaining improved resilience to floods: a proactive multi-stakeholder approach, Disaster Prev. Manag.: Int. J. 18 (1) (2009) 9–22.
[81] M.K. Lindell, S.N. Hwang, Households' perceived personal risk and responses in a multihazard environment, Risk Anal.: Int. J. 28 (2) (2008) 539–556.
[82] T. Terpstra, M.K. Lindell, J.M. Gutteling, Does communicating (flood) risk affect (flood) risk perceptions? Results of a quasi-experimental study, Risk Anal.: Int. J. 29 (8) (2009) 1141–1155.
[83] R. Miceli, I. Sotgiu, M. Settanni, Disaster preparedness and perception of flood risk: a study in an alpine valley in Italy, J. Environ. Psychol. 28 (2) (2008) 164–173.
[84] J. Ludy, G.M. Kondolf, Flood risk perception in lands "protected" by 100-year levees, Nat. Hazards 61 (2) (2012) 829–842.
[85] W. Botzen, J. Aerts, J. Van Den Bergh, Dependence of flood risk perceptions on socioeconomic and objective risk factors, Water Resour. Res. 45 (10) (2009).
[86] M.C. Ho, et al., How do disaster characteristics influence risk perception? Risk Anal.: Int. J. 28 (3) (2008) 635–643.
[87] R. Bradford, et al., Risk perception–issues for flood management in Europe, Nat. Hazards Earth Syst. Sci. 12 (7) (2012) 2299–2309.
[88] B. Braun, T. Aßheuer, Floods in megacity environments: vulnerability and coping strategies of slum dwellers in Dhaka/Bangladesh, Nat. Hazards 58 (2) (2011) 771–787.
[89] F.H. Norris, et al., Community resilience as a metaphor, theory, set of capacities, and strategy for disaster readiness, Am. J. Community Psychol. 41 (1–2) (2008) 127–150.
[90] S.L. Cutter, et al., A place-based model for understanding community resilience to natural disasters, Glob. Environ. Chang. 18 (4) (2008) 598–606.
[91] M. Pelling, What determines vulnerability to floods; a case study in Georgetown, *Guyana*, Environ. Urb. 9 (1) (1997) 203–226.
[92] A. Steinführer, Social Vulnerability and the 2002 Flood. Country Report Germany (Mulde River). T11-07-08, 2007.
[93] J. Birkmann, et al., Framing vulnerability, risk and societal responses: the MOVE framework, Nat. Hazards 67 (2) (2013) 193–211.
[94] Y. Nakagawa, R. Shaw, Social capital: a missing link to disaster recovery, Int. J. Mass Emergencies Disasters 22 (1) (2004) 5–34.
[95] A. Arbaiah, Ar daud, A. surinah, U. Noorhaida, Shaharom Namcd, Health preparedness and response to flood disaster in Johore, Malaysia□: challenges and lessons learned, Malays. J. Commun. Health Public 15 (2009) 126–131.
[96] B.K. Paul, D.J. Rumsey, Utilization of health facilities and trained birth attendants for childbirth in rural Bangladesh: an empirical study, Soc. Sci. Med. 54 (12) (2002) 1755–1765.
[97] R.H. Ofrin, I. Nelwan, Disaster risk reduction through strengthened primary health care, in: Regional Health Forum, World Health Organization Regional Office for South-East Asia, 2009.
[98] J. Roukema, Effects of Improved Accessibility to Health Services provided by Trail Bridges Final Report, 2008 (Nepal).
[99] W. Shao, et al., Understanding the effects of past flood events and perceived and estimated flood risks on individuals' voluntary flood insurance purchase behavior, Water Res. 108 (2017) 391–400.
[100] W. Shao, et al., A sequential model to link contextual risk, perception and public support for flood adaptation policy, Water Res. 122 (2017) 216–225.
[101] Government of Khyber Pakhtunkhwa, Monsoon Contingency Plan, 2018. Available at: https://reliefweb.int/report/pakistan/provincial-disaster-management-authority-government-khyber-pakhtunkhwa-544 monsoon-0.
[102] Khyber Pakhtunkhwa Provincial Disaster Management Authority, Monsoon Contingency Plan KP, 2014, p. 540. Available at: http://www.pdma.gov.pk/sites/default/files/Monsoon_Contingency_Plan_KP_2014.pdf.