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RESEARCH ARTICLE

Effect of 'losses' and other secondary stressors on the association between flooding and psychological health outcomes: a cross-sectional study in Bongaigaon District, India

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Abstract

Fluvial flooding is a recurring event in the Aie River basin in Assam, India. On August 14, 2021, floodwater breached a large stretch of embankment in the Bongaigaon District and inundated several villages. Using a cross-sectional design to conduct household surveys in February and March 2022, the study investigates responses six to seven months following the August 2021 flood disasters. The purpose of this study is to determine the prevalence and risk factors of four psychological health outcomes. Being flooded is strongly and adversely associated with each of these mental health outcomes. After adjusting for the potential confounders, the strength of the relationships is reduced to four times (adjusted OR 4.62 [95% CI 2.63–8.1]; $p < 0.01$) for PTSD, five times (adjusted OR 5.28[95% CI 3.38–8.26]; $p < 0.01$) for anxiety, and three times (adjusted OR 3.45[95% CI 2.24–5.33]; $p < 0.01$) for depression, and 21 times for comorbid PTSD, anxiety, and depression (adjusted OR 21.68[95% CI 7.38–63.74]; $p < 0.01$). The robustness of flood exposure is checked in an extended model. It includes variables that indicate the severity of flooding and various secondary stressors. The present study also explores the effects of 'loss stressors' such as crop loss, workday loss, livestock loss, and damage to infrastructure. Located in a resource-constrained setting, the effects of these factors add value to the study. Longer duration of floodwater in the house premise increases the odds of developing anxiety (adjusted OR 1.69[95% CI 1.04–2.75]; $p < 0.05$) and depression (adjusted OR 1.9[95% CI 1.15–3.12]; $p < 0.05$). Similarly, deeper floodwater inside the house increases the odds of depression (adjusted OR 1.87[95% CI 1.07–3.28]; $p < 0.05$). Among all the 'loss' stressors, damage to houses and the cost of repairing is significantly associated with PTSD (adjusted OR 2.04[95% CI 1.09–3.82]; $p < 0.05$), depression (adjusted OR 2.17[95% CI 1.22–3.87]; $p < 0.01$) and comorbid PTSD, anxiety and depression (adjusted OR 2.16[95% CI 1.07–4.36]; $p < 0.05$).

Keywords: Anxiety; Assam flood; depression; mental health; psychiatric comorbidity: post-traumatic stress disorder; 'loss stressors'

Background

Floods are one of the most common and deadliest disasters globally. According to the Centre for Research on the Epidemiology of Disasters report, with 176 events, floods dominated all catastrophic events reported in 2022, globally (CRED, 2023). Flooding claimed lives; for instance, worldwide, 7954 lives succumbed to floods in 2022, and in India alone, 2035 lives were lost due to flooding (CRED, 2023). Besides destroying lives and properties, many health effects are associated

with flooding (Ahern *et al.,* 2005). Flooding leads to the deterioration of mental health (Stanke *et al.,* 2012). Studies show that among flood victims, the prevalence of psychological morbidities such as post-traumatic stress disorder (PTSD), anxiety, and depression is higher than among non-exposed people (Fernandez *et al.,* 2015; Stanke *et al.,* 2012).

Additionally, exposure to disasters always results in comorbid PTSD and other psychological disorders (Dai *et al.,* 2017). For example, 6.5 per cent of participants satisfied the criterion for comorbid PTSD and anxiety 18 years after the *Dongting* Lake flood in China (Dai *et al.,* 2017a, 2017b). Psychiatric comorbidity is significantly correlated with flood exposure among Pakistani flood victims (Man Cheung *et al.,* 2014). These studies offer evidence that PTSD can co-occur with a variety of diseases, including anxiety and depression, which may manifest in response to or as a consequence of PTSD (McMillen *et al.,* 2002). Given the high frequency and destructiveness of flood events, there are fewer studies to quantify the mental health effects of flooding, especially among low-and middle-income countries (Ahern *et al.,* 2005).

Several parts of India regularly experience floods due to brief and intense monsoon rains. Extreme precipitation events and other factors associated with catchment characteristics cause frequent flooding in the Indian subcontinent, and the trend will likely continue under a warming climate in India (Ali *et al.,* 2019). Increased frequency of flooding widens the knowledge gap already present regarding the consequences of flooding on mental health. A limited number of studies conducted in India show increased adverse mental health effects after the flood events. For example, one year after the Uttarakhand flooding, a 70.9 per cent prevalence of post-traumatic stress disorder was reported (Srivastava *et al.,* 2015). The prevalence of depression and anxiety reported was 33 per cent and 31 per cent, respectively, six months after the *Kodagu* flood (Thomas *et al.,* 2021). Among the plethora of psychological health outcomes, PTSD is the most common outcome reported in prior studies from India (Ashok *et al.,* 2019; Jose & Fenn, 2021; Mathew *et al.,* 2021; Patel *et al.,* 2015; Srivastava *et al.,* 2015).

Assam state in northeastern India experiences recurring fluvial floods due to the Brahmaputra River and its tributaries, which overflow and engulf a significant basin area (Government of India, 1980). According to the National Commission on Floods (1980), the state has around 3.105 million hectares of flood-prone land area out of 7.8 million hectares (Government of India, 1980). Flooding caused by the breach of the River *Aie* embankments, a Brahmaputra tributary, devastated several villages in the Bongaigaon Districts of Assam on August 14, 2021. Two more waves of floods of lesser severity hit the same area in 2021.

Studies conducted by various scholars observed that the prevalence of psychological morbidity is very high in various parts of India among the flood-affected population (Jose & Fenn, 2021; MN & Sekar, 2012; Srivastava *et al.,* 2015). Most studies in India lack a control population for comparison, except for a few (JoyJ *et al.,* 2021; Wind *et al.,* 2013). Following these observations, a recent review article noted that a methodological flaw in most of the studies on this subject from low-and middle-income countries is the absence of an unexposed group for comparison (Sharpe & Davison, 2021). The present study addresses this gap.

The known risk factors are socio-economic and demographic characteristics of the study population that are associated with adverse mental health outcomes after flooding, such as educational attainment, employment, income, current marital status, gender, underlying health conditions, and age (Paranjothy *et al.,* 2011; Dai *et al.,* 2016; Yoda *et al.,* 2017; Ashok *et al.,* 2019; Norberg *et al.,* 2021). Although mentioned in the literature, the variables related to the details of flood-related losses are not adequately reflected in previous models (Lebowitz *et al.,* 2019; Cherry *et al.,* 2021). Losses sustained may have less of an impact on people's mental health due to the availability of flood insurance in high income countries, where the majority of the literature on the topic originates, which may account for why they receive less attention in discussions. The details of financial loss are shown in four categories. Loss of work days is commonly reported among flood-affected participants. Due to water logging, local businesses are impacted, which raises unemployment (Peek-Asa *et al.,* 2012). Water logging causes livestock loss, and water logging

combined with flood-induced sand deposition causes crop loss. Prolonged contact with floodwater dampens the walls and floors; in the absence of insurance, the cost of rebuilding and restructuring falls on the already vulnerable population. Losses incurred therefore can put added stress on mental health. Factors related to preparedness and flood control in the pre-impact phase, such as flood warning and flood-related displacement in the post-impact phase, are found to be significantly associated with symptoms of depression, anxiety, and post-traumatic stress disorder (Paranjothy *et al.,* 2011; Foudi *et al.,* 2017; Tong, 2017). Receiving early warning of a flood is a protective factor, and displacement during a flood is a risk factor for the development of mental health conditions (Munro *et al.,* 2017).

This study is designed to quantify the mental health effects of flooding and investigate the impacts of flooding and several risk factors. The purpose of this study is to determine the prevalence of possible PTSD, anxiety, and depression in flood-affected people and compare it to non-flooded people. The study furthermore estimates the prevalence of comorbid PTSD, anxiety, and depression and investigates their risk factors. The study's findings will contribute to three strands of literature: the prevalence of psychiatric morbidity and comorbidity symptoms in flood victims, the effects of repeat flooding on mental health, and the risk and protective factors of psychiatric health in a resource-constrained study setting. The applicability of such studies in formulating policy on the healthcare needs of flood-affected people is tremendous. Estimating the risk of flooding on mental health and identifying the risk factors can help manage future risks.

Research method and techniques

Study design

The study utilized a cross-sectional design with a controlled population. A field survey was conducted in February and March 2022, about six to seven months after the August 2021 flood.

Setting

Flooding is a recurring phenomenon in the *Aie* River basin. Bongaigaon District is predominantly rural, with just 13.8 percent of the population as per Census 2011 living in urban areas. The ever-changing braided nature of rivers draining the region is the primary cause of recurring floods. Additionally, the sudden release of dam water from the upstream areas in Bhutan causes floods in Bongaigaon. The rural characteristic of the population, reliance on farming and limited opportunities for diversification to other occupations expose them to risks. Even though most people's income comes from agriculture, 66 percent of all landowners possess less than one hectare of cultivable land (Government of Assam, 2022).

On August 14, 2021, flooding hit several villages in Bongaigaon District in the western part of Assam. Two more waves, but of lesser severity, arrived, the last one in November. The flood-affected villages are located in Srijangram and Manikpur Development Blocks. Balajani Chechapani, Hura Mara I, Hura Mara II, Nachankuri No. III and Hapachora are five flood-affected villages chosen at random for study. Donkinamari, Thakurani Khora Para, Kaimari Lohra Para, and Fouzdar Dewan Para are the four non-flooded villages chosen as the control group. A field visit was done on the second week of September 2021 to identify the flood-affected and non-flooded villages. Data collection started six months after the August flood, in February and March 2022. It was a one-shot data collection, and no follow-up was carried out. The researcher conducted face-to-face interviews along with two other field investigators who belong to the area and are fluent in the local dialect. All three interviewers' mother tongue is Assamese.

Participants

To select participants, two-stage cluster random sampling is used for greater precision. Five villages (Primary Sampling Units) from Bongaigaon District's Srijangram Development Block and Manikpur Development Block were chosen in the first round. Among the flood-affected villages, five villages were chosen randomly as 'exposed' villages and four nearby non-flooded villages were chosen as 'control' villages. In the second stage, two lists of sample households are identified from the primary sampling units: one for exposed villages and one for the control villages. The number of sample households from exposure categories is determined using the probability proportion to size (PPS) method, which is based on data from the 2011 Primary Census Abstract. No attempts have been made to re-visit a household if it was found empty on the first visit; instead, a neighbouring household was visited for data collection. Besides, information was collected only among those participants who were present during the time of the survey. The criteria for inclusion of participants from sampled households are: a) being above 18 years of age; b) consenting to participate. Total participants constitute 37.72 per cent of the sample population (N).

Variables

Three outcome variables are included in the study: PTSD, anxiety, and depression. Three validated instruments were used to assess the presence or absence of probable PTSD, anxiety, and depression in the participants. Prior research used the Patient Health Questionnaire (PHQ-4) for depression and anxiety and the Post-Traumatic Stress Disorder Checklist (PCL-5) for PTSD (Munro *et al.,* 2017; Cherry *et al.,* 2021; Mahmood *et al.,* 2022). The PHQ-4 includes a two-item depression scale and a two-item Generalized Anxiety Disorder (GAD-2) scale to measure depression and anxiety. 'Not at all', 'several days', 'more than half the days' and 'almost every day' are the four alternatives on the scale, which range from 0 to 3. The four-item abridged version of PCL-5 assesses four Diagnostic and Statistical Manual of Mental Disorders-V (DSM-V) symptoms of PTSD. PCL-5 provides five alternatives ranging from 'not at all' to 'very', ranging from 0 to 4. The validated cut-off scores for PHQ-2 and GAD-2 are $\geq$3 and for PCL-5 (four-item) is $\geq$10 (Price *et al.,* 2016; Munro *et al.,* 2017). Probable anxiety, depression, and PTSD are diagnosed based on the validated cut-off score. Therefore, the dependent variable is a binary variable coded with 1 if the participant has the condition and with 0 if not. Because the tools are screening instruments rather than clinical diagnoses, cases of PTSD, anxiety, and depression are referred to as 'probable' cases of PTSD, anxiety, and depression (Tempest *et al.,* 2017). The questionnaires were translated into Assamese (Assamese language) by following the standard procedure. The Assamese versions of the questionnaires were used on the ground. Field investigators completed mental health questionnaires based on information supplied by participants.

A thorough review of the literature on the impact of flooding on mental health and risk factors from 2010 to 2021 served as the foundation for selecting independent variables for each of the four mental health problems. The characteristics of independent variables are presented in Table 1.

Individuals' physical health and underlying health conditions were also found to influence their mental health after flooding (Ashok *et al.,* 2019; Mason *et al.,* 2010). The prevalence of these health conditions was reported during the household survey, they are- fractured hand and leg; person rescued from drowning but the water went into the windpipe; cuts and injury; body pain; weakness; gastrointestinal symptoms (upset stomach, vomiting, nausea); diarrhoea/dysentery/loose stools; jaundice; typhoid; malaria; other skin infection and irritation (not tinea pedis); eye infection. Chronic and long-term health conditions identified among the participants are- hypertension, asthma, low blood pressure, diabetes, heart condition, paralysis, TB, liver problems, blindness, epilepsy, birth deformity, cancer, chest pain, and nerve problems.

Table 1. Description and Characteristics of Explanatory Variables Used in the Analysis to Find Out Risk and Protective Factors of Mental Health Outcomes

Parameters	Indicators	Types of Variable
Severity of flooding	1) Depth of flood water inside the house; 2) duration of flood water in house premise	Categorical Categorical
Warning and displacement	3) status of flood warning; 4) status of displacement;	Categorical Categorical
'Loss' stressors arising after flooding	5) crop lost; 6) livestock lost; 7) workdays lost; 8) damage to houses that needed repairing	Categorical dichotomous
Socio-economic economic characteristics of household	9) income; 10) duration of stay at the current place of residence	Categorical Categorical
Demographic characteristics of participants	11) age; 12) gender; 13)marital status; 14) education attainment 15) disease prevalence after flood; 16) presence of chronic illnesses or long-term health conditions	Categorical Categorical dichotomous Categorical Categorical Categorical dichotomous Categorical dichotomous

'Displacement' is another possible risk factor; 'displacement' in the context means displacement and evacuation during flooding to relief camps, higher ground such as embankments or roads, and relatives' houses, most of whom return to their homes post-floods. A few of these displaced people who incurred damage to houses or other severe losses had to relocate for an extended period (or permanently) even after the floodwater receded, which can be captured in their stay at their current residence. It is logical to think that those who stayed less than one year at their current residence have recently relocated due to the 2021 flooding. This is the logic behind using 'displacement' and 'duration of stay at current place of residence' as two separate independent variables. 'Duration of stay at current place of residence' is captured at the household level; for example, even if someone is 30 years old, if the household has been at that location for 50 years, 50 years is taken irrespective of the participant's age. Therefore, there is a discrepancy in the participant's ages and the years of their stay at their current place.

Although continuous, the variables related to age, income, and the duration of stay in the current place of residence are converted into categories because the association with the dependent variable may not be linear. Duration of current place of residence less than one can also be used as a proxy for relocation after flooding.

Data sources

Information on outcome variables was collected by using three screening tools, and information on independent variables was collected using a semi-structured questionnaire. The same screening tools and questionnaires were used for both the 'exposed' and 'controlled' populations, except information relevant in the context of flood was not collected from the 'controlled' population.

Study size

A sample size of 362 people is calculated with an anticipated prevalence rate of flood-related psychological morbidity of 50 per cent and a margin of error of 5 per cent; the total population is

6406 in the five exposed villages. Cochran's formula for finite population calculates the sample size (Cochran, 1977). After accounting for the household response rate of 90 per cent, the required sample size for the exposed population is worked out to be 400. After considering the same sample size for the control group, the total sample size was estimated to be 800.

Statistical methods

The prevalence of the three mental health outcomes is calculated as a percentage, separately for both the exposed and control populations. The internal reliability of the variables in the three scales is calculated using Cronbach's alpha values. The correlation matrix was constructed to understand the correlation between the items of the three scales. Since the dependent variables are dichotomous, logistic regression to determine the odds ratios are calculated and adjusted for potential confounders. Two separate logistic regression analyses were performed: Model I included all controlled and exposed participants. To check the robustness of flood exposure and its effects on mental health, Model II includes only flood-exposed participants; thus, in Model II, variables indicating the severity of flooding and various secondary stressors that are only relevant in the context of a flood are included. All logistic regression analysis is performed in STATA IC 16 (StataCorp, College Station, TX).

Results

Internal reliability and validity of the screening tools

The internal reliability of the variables in the three scales is calculated. The PCL-5 scale, two-item anxiety scale, and two-item depression scale had Cronbach's alpha values of 0.88, 0.649, and 0.544, respectively. The correlation matrix was constructed to understand the correlation between the items of the three scales; the inter-item correlation of PCL-5 items ranged from 0.58 to 0.76 (all correlations were significant at a .01 level). Similarly, for the two-item depression scale and GAD-2, the inter-item correlation is 0.48 and 0.38, respectively (significant at the .01 level). Descriptive statistical analysis on individuals' demographic, social and economic background characteristics and mental health outcomes such as probable anxiety, depression, and PTSD is conducted separately for the control and exposed populations to assess the mental health impact of flooding. Categorical variables are presented as frequencies and corresponding percentages. The association of all three outcome variables with explanatory factors is tested using the chi-square test, $p < 0.05$ is considered statistically significant.

Characteristics of study participants

A total of 866 people participated in the mental health survey. Out of the total, 450 participants were from flood-affected households and 416 from non-flooded households. Total participants constitute 37.72 per cent of the sample population (N). Table 2 presents the socio-economic and demographic characteristics of the exposed and controlled participants separately. A higher proportion of participants are females in exposed (54.89 per cent) and controlled (56.01 per cent) categories. Most of the controlled participants (88.22 percent) belong to households that have stayed in their current place of residence for more than 50 years, while a higher proportion of the exposed participants (57.33 percent) come from households that have stayed for 10 to 50 years. A large share of the participants is illiterate among exposed participants (27.78). The majority of the exposed participants are aged between 18 and 35 years (45.11 per cent) and married (82.89 per cent). Among exposed participants, 12.2 per cent have reported chronic illness and long-term health conditions, which is significantly higher than controlled participants. The prevalence of chronic conditions among controlled participants is 4.81 per cent. About 9.56 per cent of the exposed participants experienced at least one of these health conditions after flooding: fractured

Table 2. Demographic and Socioeconomic Characteristics of Study Population, by Exposure Categories, Bongaigaon District Assam, 2022

Characteristics (n)	Flooded, n (%)	Non-flooded, n (%)	p-value
Sex			
Male (386)	203 (45.11)	183 (43.99)	0.740
Female (480)	247 (54.89)	233 (56.01)	
Income			
First quartile (<8K) (262)	155 (34.44)	107 (25.72)	0.019
Second quartile (8–11K) (174)	93 (20.67)	81 (19.47)	
Third quartile (11–16K) (218)	104 (23.11)	114 (27.4)	
Fourth quartile (16–165K) (212)	98 (21.78)	114 (27.4)	
Duration of stay at current place of residence			
Less than one year (20)	20 (4.44)	0 (0)	.000
1–10 years (48)	46 (10.22)	2 (0.48)	
10–50 years (305)	258 (57.33)	47 (11.3)	
More than 50 years (493)	126 (28)	367 (88.22)	
Education			
Illiterate (196)	125 (27.78)	71 (17.07)	<0.0001
Up to class X (428)	235 (52.22)	193 (46.39)	
High School pass (242)	90 (20.00)	152 (36.54)	
Age			
18–35 years (372)	203 (45.11)	169 (40.63)	0.0606
36–60 years (367)	193 (42.89)	174 (41.83)	
More than 60 years (127)	54 (12.0)	73 (17.83)	
Marital status			
Married (667)	373 (82.89)	294 (70.67)	0.00010
Never married (108)	41 (9.1)	67 (16.11)	
Widow (91)	36 (8.0)	55 (13.22)	
Presence of chronic illnesses or long-term health conditions			
Yes (75)	55 (12.2)	20 (4.81)	0.000
No (791)	395 (88.0)	396 (95.19)	
Disease prevalence after flood			
Yes (51)	43 (9.56)	8 (1.92)	0.000
No (815)	407 (90.44)	408 (98.08)	

Source: Primary survey, February-March, 2022

hand and leg; person rescued from drowning but water went into the windpipe; cuts and injury; body pain; weakness; gastrointestinal symptoms (upset stomach, vomiting, nausea); diarrhoea/dysentery/loose stools; jaundice; typhoid; malaria; other skin infection and irritation (other than tinea pedis); and eye infection. A significantly lesser share (1.92 per cent) of controlled participants reported these conditions.

Prevalence of psychological morbidity by explanatory variables

The crude prevalence of all four psychological morbidity conditions is significantly higher among the flood-affected participants (Table 3); probable PTSD (28.44 vs 5.53 per cent; $p < .001$), probable anxiety (48 vs 10.58 per cent; $p < .001$), probable depression (39.11 vs 13.46 per cent; $p < .001$), and probable PTSD, anxiety and depression (20.67 vs 0.96; $p < .001$). Participants with a long history of staying at their current place of residence have a higher prevalence rate of all four mental health conditions ($p < .001$). Among the participants' socio-demographic conditions, illiterate and married participants reported a higher prevalence of all four conditions ($p < .001$). Crude prevalence rates of mental health conditions are also higher among participants reporting the presence of chronic illness ($p < .05$) and various infectious diseases after flood ($p < .05$).

Among the flood-exposed participants, the crude prevalence rates of all four mental health conditions are higher among those reporting more than one-week duration of floodwater inside the house premise (PTSD, $p = .002$; anxiety, $p = .002$ depression, $p = .000$; comorbidity, $p = .005$), participants reporting more than 100 cm of floodwater inside the house (PTSD, $p = .000$; anxiety, $p = .002$ depression, $p = .000$; comorbidity, $p = .001$) (Table 4), participants reporting damage to houses by flooding (PTSD, $p = .02$; anxiety, $p = .026$ depression, $p = .004$). There is no significant difference in the crude prevalence rates between participants reporting crop, livestock, and workday loss and those who did not experience any of these losses. There is no significant difference in prevalence rates among participants who did not receive any early warning, participants who received a reliable warning and who received an unreliable warning before flooding. Table 4 shows that there is no significant difference in the prevalence of the four health conditions between participants who were displaced and those who were not.

Risk factors

Risk and protective factors among exposed and controlled groups (Model I)

Being flooded is strongly and adversely associated with each of these mental health outcomes; PTSD, anxiety, and depression are two to five times higher, and the presence of psychiatric comorbidity is 21 times higher in flood-affected areas compared to non-flooded areas (Figure 1a, b, c, and d). After adjusting for the potential confounders, the strength of the relationships is reduced to four times (adjusted OR 4.62 [95% CI 2.63–8.1]; $p < 0.01$) for PTSD, five times (adjusted OR 5.28[95% CI 3.38–8.26]; $p < 0.01$) for anxiety, and three times (adjusted OR 3.45[95% CI 2.24–5.33]; $p < 0.01$) for depression. Flood-affected people are more likely to develop comorbid PTSD, anxiety, and depression (adjusted OR 21.68[95% CI 7.38–63.74]; $p < 0.01$).

Among the socioeconomic variables, education has a significant association with PTSD, anxiety, and comorbidity; the illiterate participants have higher odds of developing PTSD (adjusted OR 2[95% CI 1.08-3.7]; $p < 0.05$), anxiety (adjusted OR 1.94[95% CI 1.13–3.35]; $p < 0.05$), and comorbidity (adjusted OR 2.78[95% CI 1.28–6.05]; $p < 0.05$). Poor participants have higher odds of developing anxiety; the association is significant for participants belonging to the first quartile (adjusted OR 1.69[95% CI 1.04–2.73]; $p < 0.05$). Duration of stay at current place of residence is significantly associated with all four mental health conditions. Compared to participants who have stayed in the current place of residence for more than 50 years, the odds of developing anxiety (adjusted OR 5.51[95% CI 1.68–18.08]; $p < 0.01$), depression (adjusted OR 6.41[95% CI 1.98–20.92]; $p < 0.01$) and comorbidity (adjusted OR 2.86[95% CI 1–8.18]; $p < 0.05$) is higher among those who have stayed for less than one year. Participants reporting one to 10 years of staying at the current place of residence have two times higher odds of developing PTSD (adjusted OR 2.66[95% CI 1.29–5.51]; $p < 0.01$, five times higher odds of developing anxiety (adjusted OR 5.6[95% CI 2.57–12.17]; $p < 0.01$, and three times higher odds of developing depression (adjusted OR 3.96[95% CI 1.94–8.06]; $p < 0.01$, compared to those who have stayed for more than 50 years (Appendix Table 1).

Table 3. Prevalence of Psychological Morbidity among all Participants by Explanatory Variables

Explanatory variables	Probable PTSD, n(%) (total cases = 151)	Probable Anxiety,n(%) (total cases = 260)	Probable Depression, n(%) (total cases = 232)	Comorbidity n(%) (total cases = 97)
Exposure to flood				
Flooded (n = 450)	128 (28.44)	216 (48.0)	176 (39.11)	93 (20.67)
Non-flooded (n = 416)	23 (5.53)	44 (10.58)	56 (13.46)	4 (0.96)
x^2	78.85	1.44	72.51	84.39
P	.000	.000	.000	.000
Sex				
Male (n = 386)	61 (15.80)	107 (27.72)	94 (24.35)	34 (8.80)
Female (n = 480)	90 (18.75)	153 (31.88)	138 (28.75)	63 (13.13)
x^2	1.29	1.76	2.11	4.01
P	.256	.185	.146	.045
Income				
First quartile (262)	55 (20.99)	91 (34.73)	81 (30.92)	36 (13.74)
Second quartile (174)	32 (18.39)	55 (31.61)	50 (28.74)	15 (8.62)
Third quartile (218)	33 (15.14)	67 (30.73)	55 (25.23)	22 (10.09)
Fourth quartile (212)	31 (14.62)	47 (22.17)	46 (21.69)	24 (11.32)
x^2	4.38	9.25	5.68	3.136
P	.223	.026	.128	.371
Duration of stay at current place of residence				
Less than one year (20)	10 (50)	16 (80)	16 (80)	10 (50)
1–10 years (48)	21 (43.75)	37 (77.08)	33 (68.75)	15 (31.25)
10–50 years (305)	70 (22.95)	120 (39.34)	87 (28.52)	44 (14.43)
More than 50 years (493)	50 (10.14)	87 (17.65)	96 (19.47)	28 (5.68)

(*Continued*)

Table 3. (*Continued*)

Explanatory variables	Probable PTSD, n(%) (total cases = 151)	Probable Anxiety,n(%) (total cases = 260)	Probable Depression, n(%) (total cases = 232)	Comorbidity n(%) (total cases = 97)
x^2	62.48	1.22	85.89	67.96
P	.000	.000	.000	.000
Education				
Illiterate (n = 196)	55 (28.06)	85 (43.37)	70 (35.71)	43 (21.94)
Up to class X (n = 428)	70 (16.36)	132 (30.84)	119 (27.80)	42 (9.81)
High School pass (n = 242)	26 (10.74)	43 (17.77)	43 (17.77)	12 (4.96)
x^2	23.25	34.05	18.23	33.03
P	.000	.000	.000	.000
Age groups				
18–35 years (n = 372)	61 (16.4)	110 (29.57)	95 (25.54)	40 (10.75)
36–60 years (n = 367)	72 (19.62)	106 (28.88)	101 (27.52)	45 (12.26)
>60 years (n = 127)	18 (14.17)	44 (34.65)	36 (28.35)	12 (9.45)
x^2	2.43	1.55	.55	.88
P	.296	.460	.758	.643
Marital status				
Married (n = 667)	126 (18.89)	216 (32.38)	193 (28.94)	87 (13.04)
Never married (n = 108)	12 (11.11)	18 (16.67)	16 (14.81)	3 (2.78)
Widow (n = 91)	13 (14.29)	26 (28.57)	23 (25.27)	7 (7.69)
x^2	4.61	11.03	9.57	11.11
P	.100	.004	.008	.004
Presence of chronic illnesses or long-term health conditions				
yes (n = 75)	28 (37.33)	39 (52)	29 (38.67)	17 (22.67)
No (n = 791)	123 (15.54)	221 (27.93)	203 (25.66)	80 (11.13)

(*Continued*)

Table 3. (*Continued*)

Explanatory variables	Probable PTSD, n(%) (total cases = 151)	Probable Anxiety,n(%) (total cases = 260)	Probable Depression, n(%) (total cases = 232)	Comorbidity n(%) (total cases = 97)
x^2	22.58	18.88	5.91	10.85
P	.000	.000	.02	.003
Disease prevalence after flood				
yes (n = 51)	15 (29.41)	23 (45.09)	20 (39.22)	10 (10.61)
No (n = 815)	136 (16.69)	237 (29.08)	212 (26.01)	87 (10.67)
x^2	5.39	5.86	4.27	3.85
P	.034	.018	.05	.064

Source: Calculated by researcher based on primary survey, February-March 2022

Table 4. Mental Health Outcomes among Flood-Affected Participants by Severity of Flooding, Displacement Status and Status of Warning Received

Explanatory factors	Probable PTSD, n(%)	Probable Anxiety, n(%)	Probable depression, n(%)	Probable co-morbidity, n(%)
Duration of floodwater at the house premise				
Less than one week (290)	68 (23.45)	123 (44.83)	93 (32.07)	48 (16.55)
More than one week (160)	60 (37.5)	93 (58.13)	83 (51.88)	45 (28.13)
x^2	10.003	10.197	16.985	8.423
P	.002	.002	.000	.005
Depth of floodwater inside the house				
Less than 100 cm (288)	63 (21.88)	122 (42.36)	90 (31.25)	45 (15.63)
More than 100 cm (162)	65 (40.12)	94 (58.02)	86 (53.09)	48 (29.63)
x^2	16.96	10.191	20.76	12.403
P	.000	.002	.000	.001
Reliability of the flood warning				
Reliable (81)	22 (27.16)	42 (51.85)	30 (37.04)	16 (19.75)
Less reliable (57)	19 (33.33)	31 (54.39)	25 (43.86)	13 (22.81)
Warning not received (312)	87 (27.88)	143 (45.83)	121 (38.78)	64 (20.51)
x^2	.782	2.00	.700	.205
P	.676	.368	.705	.903
Status of displacement				
Not displaced (290)	75 (25.86)	137 (47.24)	113 (38.97)	59 (20.34)
Displaced (160)	53 (33.13)	79 (49.38)	63 (39.38)	34 (21.25)
x^2	2.67	.188	.007	.052
P	.126	.694	1.00	.809
Crop loss				
No (288)	76 (26.39)	138 (47.92)	105 (36.46)	50 (17.36)

(*Continued*)

Table 4. (*Continued*)

Explanatory factors	Probable PTSD, n(%)	Probable Anxiety, n(%)	Probable depression, n(%)	Probable co-morbidity, n(%)
Yes (162)	52 (32.10)	78 (48.15)	71 (43.83)	43 (26.54)
x^2	1.661	.002	2.364	5.332
P	.231	1.00	.132	.029
Livestock loss				
No (176)	44 (25)	77 (43.75)	65 (36.93)	34 (19.32)
Yes (274)	84 (30.66)	139 (50.73)	111 (40.51)	59 (21.53)
x^2	1.685	2.092	.576	.321
P	.201	.176	.489	.634
Workdays loss				
No (8)	3 (37.5)	2 (25)	3 (37.5)	2 (25)
Yes (442)	125 (28.28)	214 (48.42)	173 (39.14)	91 (20.59)
x^2	.328	1.726	.009	.093
P	.693	.288	1.000	.672
Damage to house				
No (107)	21 (19.63)	41 (38.32)	29 (27.1)	15 (14.02)
Yes (343)	107 (31.2)	175 (51.02)	147 (42.86)	78 (22.74)
x^2	5.363	5.272	8.5	3.784
P	.020	.026	.004	.056

Source: Primary survey, February-March 2022

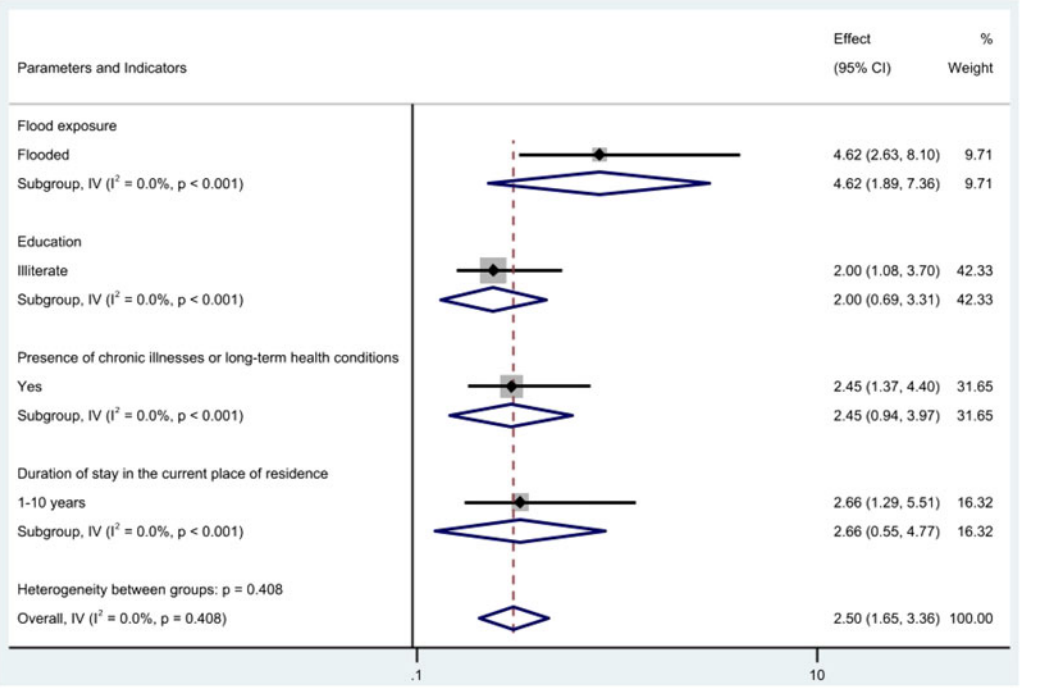

Figure 1a: Association between PTSD and Selected Socio-Demographic Variables and Flood Exposure Categories.

The presence of chronic diseases increases the odds of developing PTSD (adjusted OR 2.45[95% CI 1.37–4.4]; $p < 0.01$) and anxiety (adjusted OR 1.81[95% CI 1.02–3.2]; $p < 0.05$).

Risk and protective factors among flood-affected participants (Model II)

After adjusting for all potential confounders, the severity of flooding is significantly associated with anxiety and depression (Figure 2a, b, c, and d). Longer duration of floodwater in the house premise increases the odds of developing anxiety (adjusted OR 1.69[95% CI 1.04–2.75]; $p < 0.05$) and depression (adjusted OR 1.9[95% CI 1.15–3.12]; $p < 0.05$). Similarly, deeper floodwater inside the house increases the odds of depression (adjusted OR 1.87[95% CI 1.07–3.28]; $p < 0.05$).

Among socioeconomic and demographic variables identified and tested, the association between education, gender, presence of chronic diseases, length of stay at current place of stay and any one or more of the four mental health outcomes are found to be significant. Females are more likely to develop PTSD (adjusted OR 1.75[95% CI 1.07–2.88]; $p < 0.05$) and anxiety (adjusted OR 1.69[95% CI 1.07–2.65]; $p < 0.05$). Illiterate participants have higher odds of developing anxiety (adjusted OR 2.09[95% CI 1.07–4.1]; $p < 0.05$) and comorbidity (adjusted OR 2.44[95% CI 1.07–5.59]; $p < 0.05$). The presence of chronic diseases increases the odds of developing PTSD by two times (adjusted OR 2.48[95% CI 1.26–4.88]; $p < 0.01$). Duration of stay at current place of stay for less than one year increases odds of developing anxiety (adjusted OR 4.09[95% CI 1.17–14.29]; $p < 0.05$) and depression (adjusted OR 5.64[95% CI 1.57–20.22]; $p < 0.01$) by four and five times, compared to those whose length of stay is more than 50 years (Appendix Table 2).

Among all the 'loss' stressors, damage to houses and the cost of repairing is significantly associated with PTSD (adjusted OR 2.04[95% CI 1.09–3.82]; $p < 0.05$), depression (adjusted OR 2.17[95% CI 1.22–3.87]; $p < 0.01$) and comorbid PTSD, anxiety and depression (adjusted OR 2.16[95% CI 1.07–4.36]; $p < 0.05$).

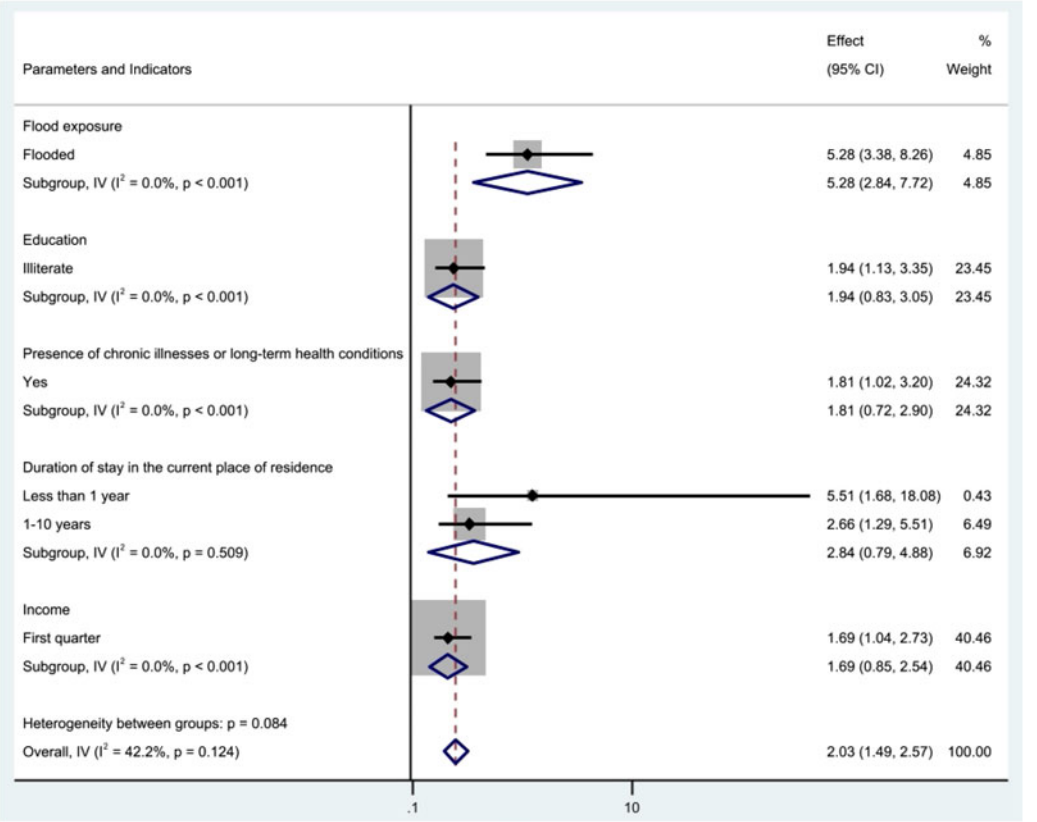

Figure 1b: Association between Anxiety and Selected Socio-Demographic Variables and Flood Exposure Categories.

Discussion

In order to address the threat that climate change poses to human health, the National Action Plan for Climate Change and Human Health (NAPCCHH) was prepared in 2018. The National Programme on Climate Change and Human Health (NPCCHH) was approved by the Ministry of Health and Family Welfare a year later. NPCCHH has created a comprehensive health action plan that helps states plan and carry out health actions to minimise health impacts, including mental health impacts (Government of India, 2019). The major components of the plan include identifying the hotspot areas of extreme weather events and the vulnerable groups that need attention. Information, Education, and communication (IEC) is an important component of NPCCHH that can be addressed by Accredited Social Health Activists (ASHA) workers and local non-governmental organizations, but such initiatives were found absent during the field survey. NPCCHH also recognizes the need for a surveillance system that can help predict the trend of psychological issues arising out of climate change. The mental health of disaster-affected people is neglected in disaster management plans in India (Thomas *et al.*, 2021), which is arguably due to the absence of academic discourse on the topic. In order to address mental health issues both during and after catastrophes, the Assam State Disaster Management Plan 2022 includes community outreach initiatives and readily available psychological support services. To assist the impacted community, the Assam State Disaster Management Authority (ASDMA) launched the MANOJNA-Psychosocial Tele Counselling Service program. State actions should be reflected in District Disaster Management Plans and updated in accordance with state guidelines. On the

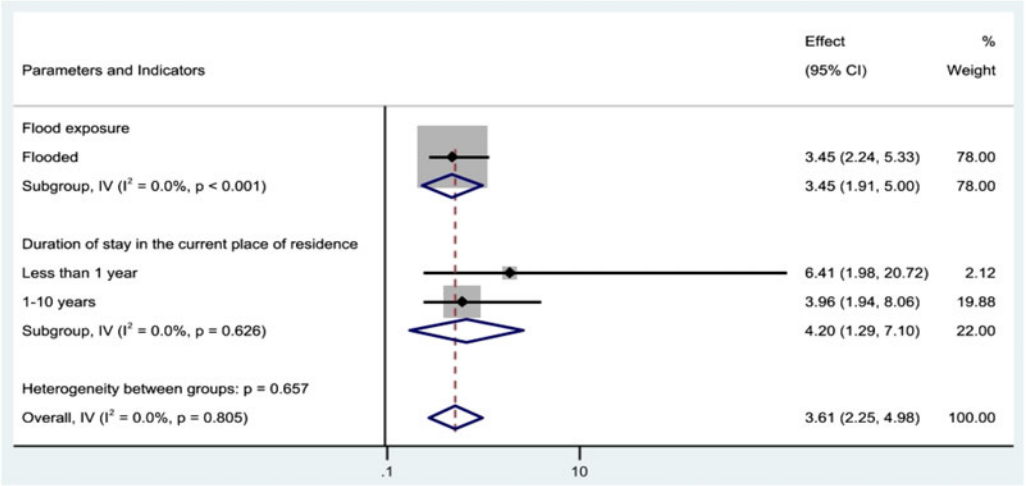

Figure 1c. Association between Depression and Selected Socio-Demographic Variables and Flood Exposure Categories.

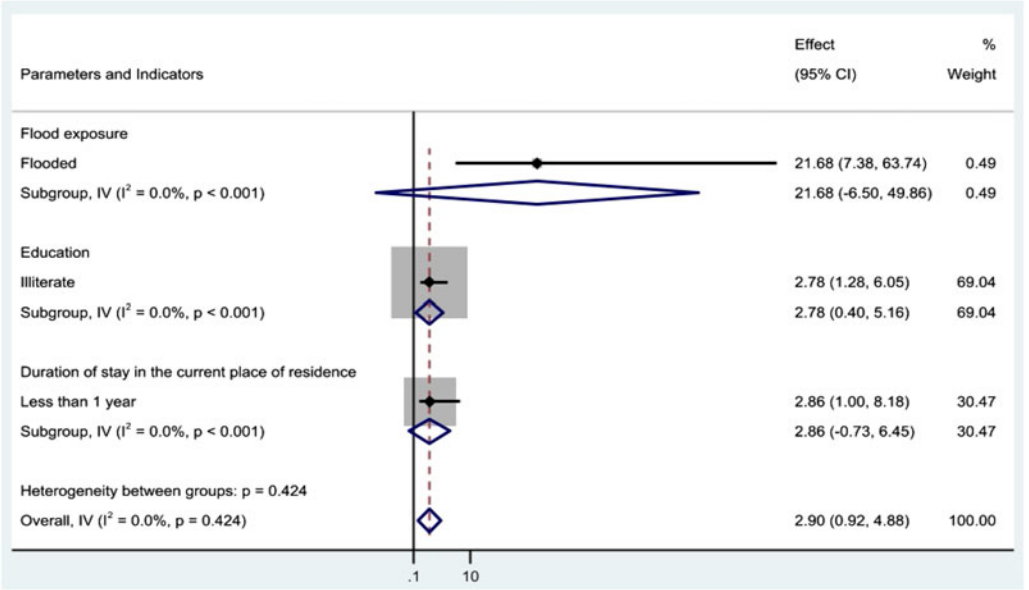

Figure 1d. Association between Co-morbid PTSD, anxiety, and depression and Selected Socio-Demographic Variables and Flood Exposure Categories.

ground level, stigma around mental health should be addressed to encourage people to seek treatment when necessary. New evidence suggests that individuals' mental health impacts their ability to prepare for upcoming calamities (James *et al.,* 2020). Therefore, public health intervention to take care of mental health among the chronically flood-affected people can help accomplish two goals simultaneously i.e., improving mental health and better disaster preparation among the chronically flood-affected population to avoid compounding impacts.

The condition of comorbidity after flood exposure is not adequately addressed in the Indian context. This study makes a humble attempt to fill that gap. Although many of the findings are

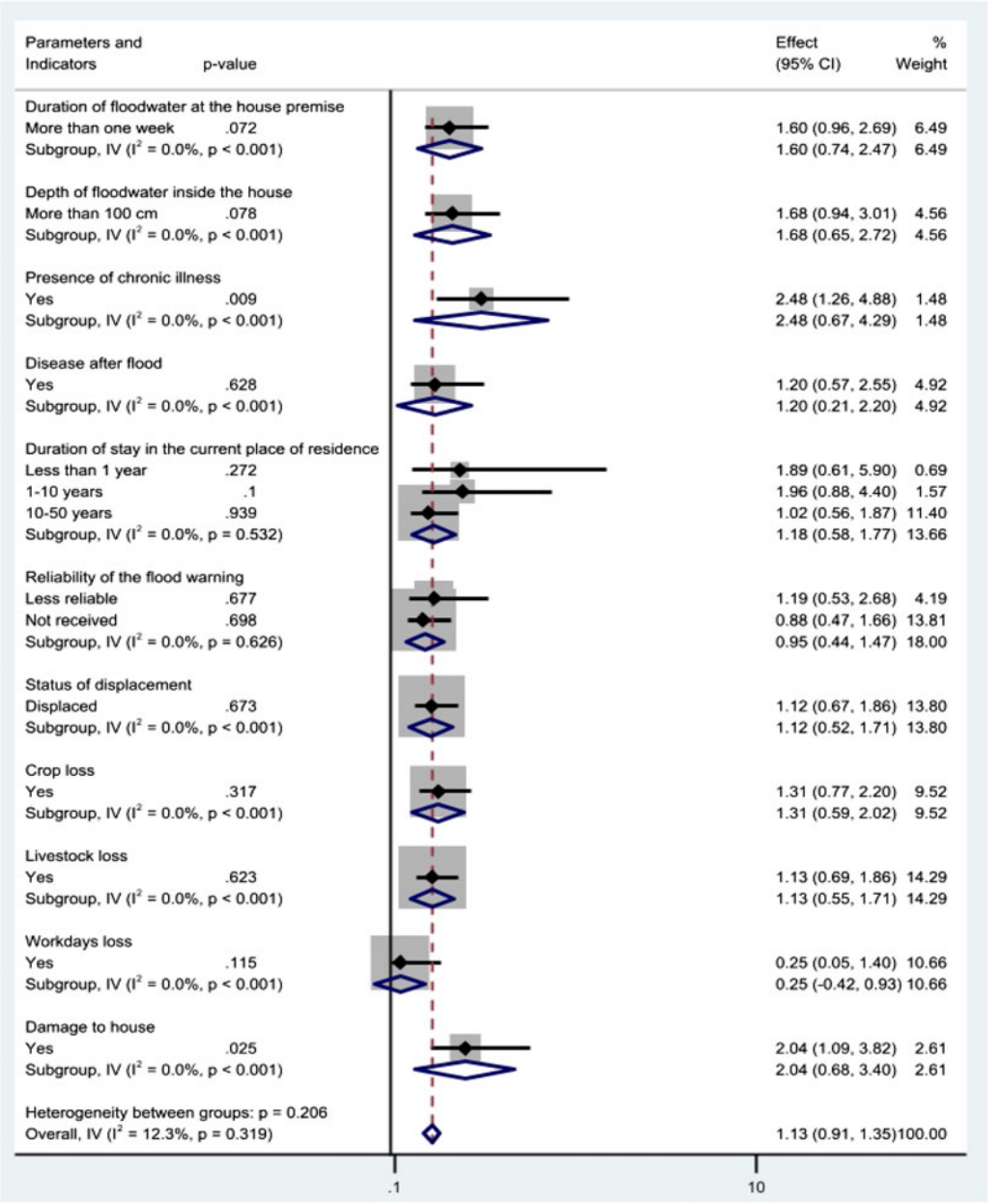

Figure 2a. Association between PTSD and Socio-Demographic Variables among the Flood Exposed Population.

consistent with the previous research, it is crucial to re-establish the facts found in the other study settings. Depression, stress, and anxiety after a flood don't very often develop into chronic illnesses. Notwithstanding, evidence from India and other parts of the World also suggests that symptoms of psychological morbidity can extend longer (Srivastava *et al.,* 2015; Dai *et al.,* 2017; Zhong *et al.,* 2018). Moreover, the mental health impacts of recurring flood events are found to be more severe (Wind *et al.,* 2013).

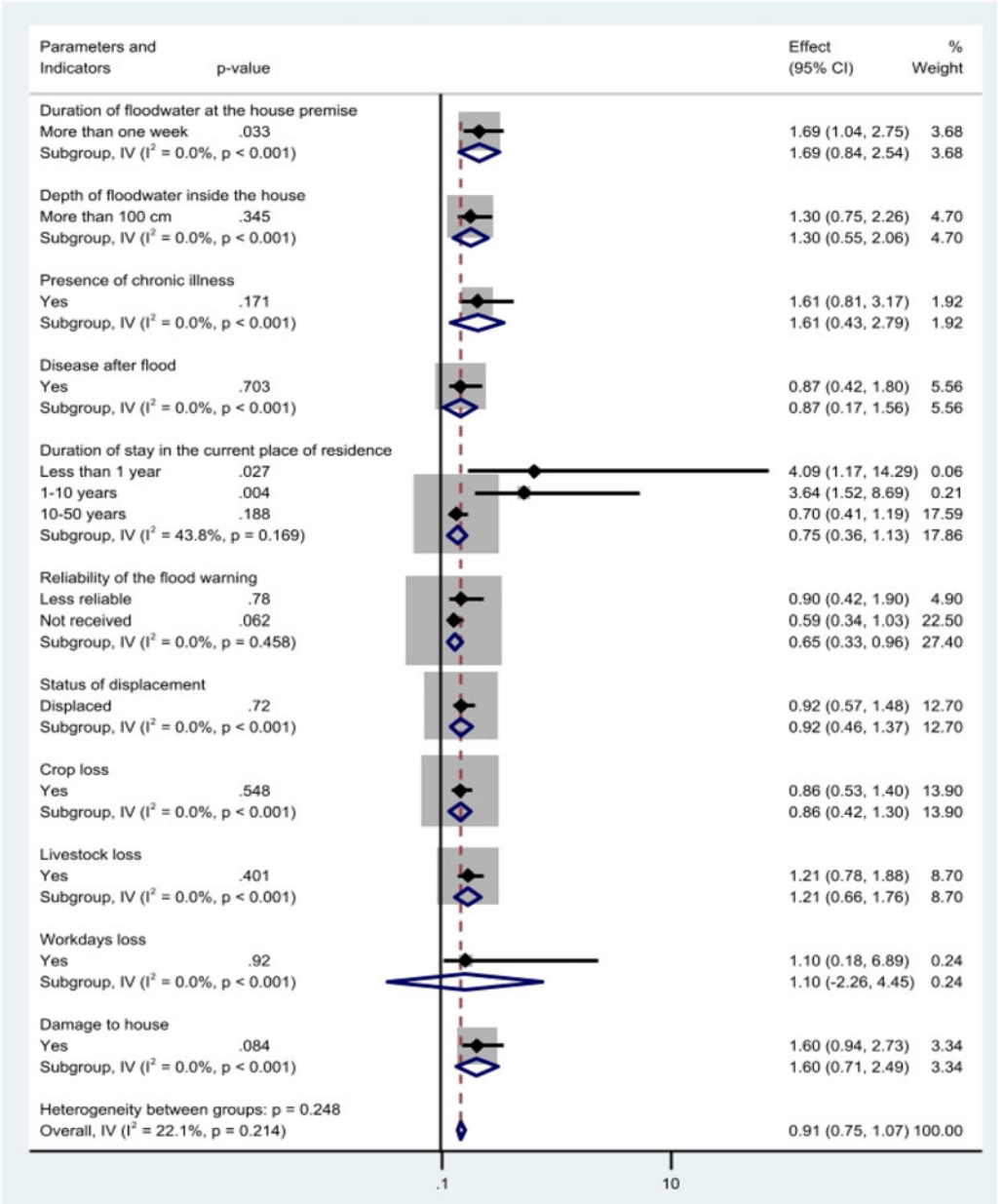

Figure 2b. Association between Anxiety and Socio-Demographic Variables among the Flood Exposed Population.

The findings of this paper show that about six to seven months after flooding, one-fifth of the research participants from the flood-affected areas exhibit comorbid PTSD, anxiety, and depression; this percentage is negligible in the non-flooded areas. Compared to anxiety and depression, PTSD is less common in both exposed and control groups. Evidence from earlier studies suggests that new disorders can develop after trauma, with or without PTSD, and that PTSD raises the likelihood of developing other disorders (McMillen *et al.,* 2002). Anxiety symptoms and depression may occur with or without PTSD, for instance: in a study based in

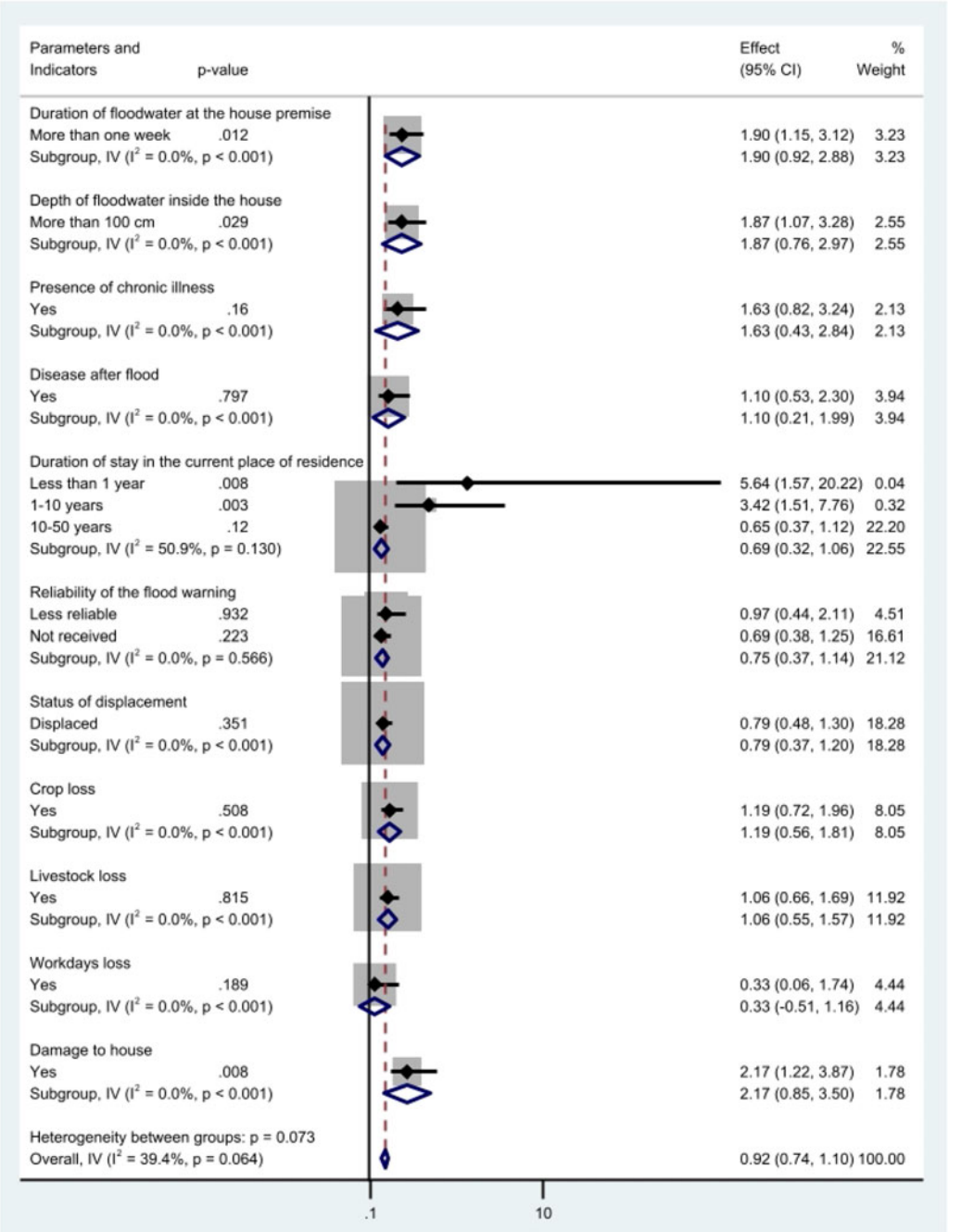

Figure 2c. Association between Depression and Socio-Demographic Variables among the Flood Exposed Population.

Canada five months after flooding, the prevalence of anxiety was higher than that of PTSD (Hetherington *et al.*, 2018). In another study based in the UK, the prevalence of probable depression was found to be higher than PTSD and anxiety (Mason *et al.*, 2010). The prevalence of anxiety and PTSD among the participants of this study is comparable to that of research conducted three to six months after the United Kingdom floods of 2007 (Paranjothy *et al.*, 2011).

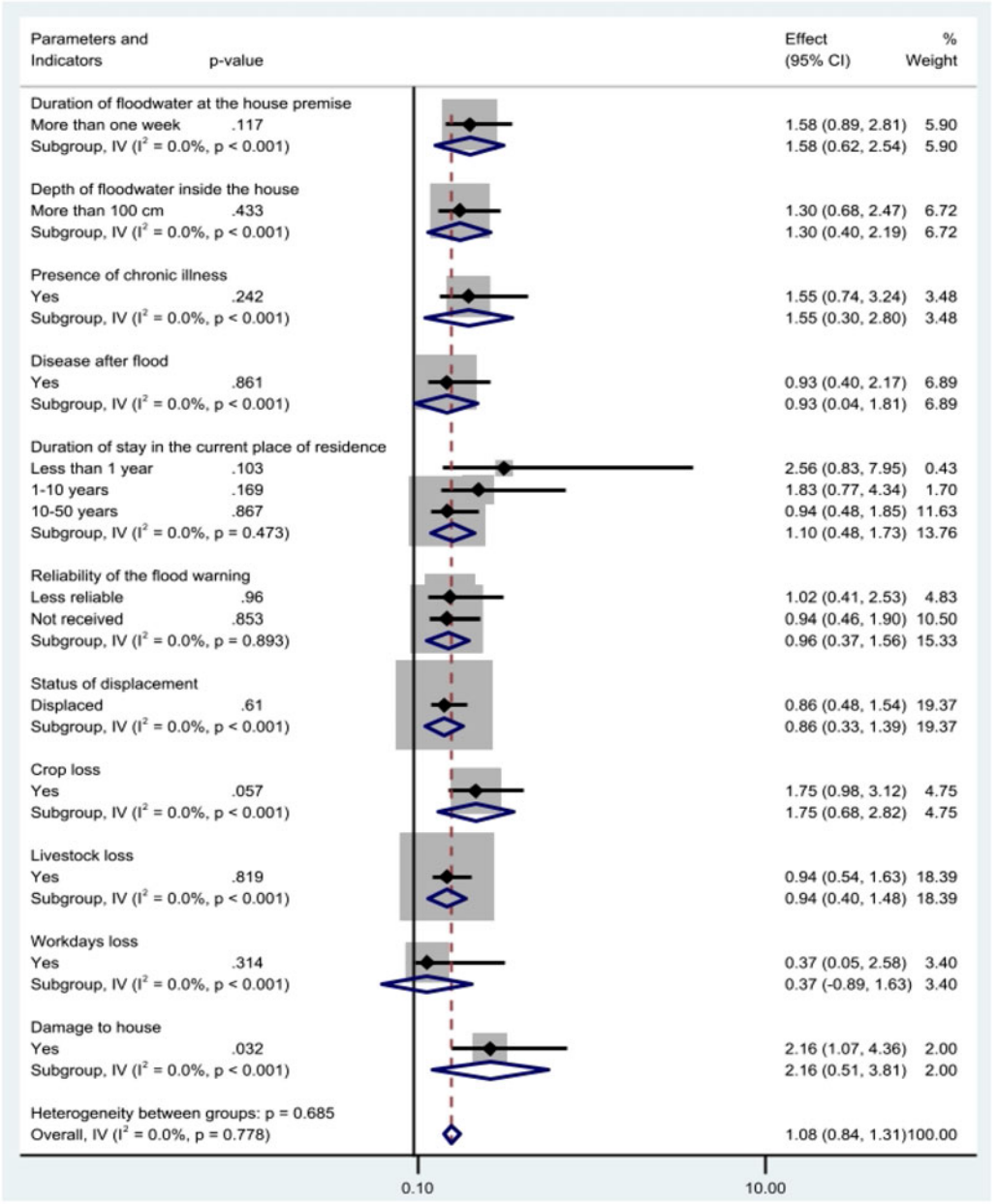

Figure 2d. Association between Co-morbid PTSD, anxiety, and depression and Socio-Demographic Variables among the Flood Exposed Population.

The prevalence of PTSD is lower than those of other studies carried out eight to 12 months after flooding in Uttarakhand, Tamil Nadu, and among adolescents after the 2018 Kerala floods (Ashok *et al.*, 2019; Srivastava *et al.*, 2015) but higher than those reported one month after the 2015 Karnataka flood (Bandla *et al.*, 2019). However, the severity of the flood events, as well as the screening tools used, is different, making all these studies incomparable. Additionally, the out-migration and resettlement of flood-affected residents in other places may cause a lower prevalence of PTSD compared to other studies.

The findings revealed that flooding elevates the risk of developing adverse mental health outcomes. The risks of developing psychological morbidity are two to five times higher among the flood-affected than among non-flooded participants. The findings are consistent with earlier studies. Previous studies conducted four to six months following a flood indicated that flood victims had two to fourteen times higher chances of getting PTSD than non-flooded victims (Fontalba-Navas *et al.,* 2017; French *et al.,* 2019; Hetherington *et al.,* 2018), two to eight times higher risks of developing depression (French *et al.,* 2019; Hetherington *et al.,* 2018), and two to four times higher risks of developing anxiety (French *et al.,* 2019; Hetherington *et al.,* 2018). The findings of this study also suggest that the risks of developing psychiatric comorbidity are 21 times higher among the flood-affected participants. The collection of data was carried out six to seven months after a severe flood in parts of the Bongaigaon District of Assam, which was followed by two more waves of non-severe floods that arrived in September and November and lasted for less than 24 hours, each. The exposed villages experienced all three waves of flooding.

Among the explanatory factors identified and tested, the duration of stay in the current place of residence, the presence of chronic illnesses or long-term health conditions, income, and level of education are found to have significant associations with one or more than one of the four psychological morbidity conditions. When compared to those who belong to households staying in the current place of residence for more than fifty years, the odds of developing PTSD, anxiety and depression are two, five, and three times higher in participants who are newer to the area (belong to households staying in their current place of residence for one to ten years). The odds of developing anxiety, depression and comorbidity are five, six and two times higher in participants who have moved to their current place of residence in less than one year compared to the participants who belong to households those have been in their current place for more than fifty years, respectively. Flood-related displacement causes residents to relocate, affecting their mental health. The recent flood forced the displacement of more than a dozen households from the Hura Mara I and Hura Mara II villages, who were residing on the river embankment at the time of the survey. They were included in the flooded population. The possible mechanisms by which floods affect mental health have been extensively researched. Displacement in the aftermath of flooding has been found to be a risk factor in earlier studies (Dar *et al.,* 2018; Lamond *et al.,* 2015; Mason *et al.,* 2010; Paranjothy *et al.,* 2011). Such displacement may also be induced by damage to houses, another risk factor for developing psychological morbidity (Lebowitz *et al.,* 2019; Woodhall-Melnik & Grogan, 2019).

Chronic illnesses or long-term health conditions significantly increase the odds of developing PTSD and anxiety, not depression. Previous research has reported a strong association between concerns about health after flooding with PTSD and depression (Paranjothy *et al.,* 2011; Dai *et al.,* 2017); the association is stronger for PTSD (Dai *et al.,* 2017). Association between underlying health issues and the development of mental illnesses is established in earlier studies (Alderman *et al.,* 2013; Yoda *et al.,* 2017). Education and income are proxy for socioeconomic development; findings show that illiterate people are more likely to develop PTSD, anxiety and comorbidity compared to those with a high school pass degree. Participants belonging to the first income quartile have higher odds of developing anxiety.

In Model II for flood-exposed populations, variables associated with the severity of flooding, and secondary stressors arising after flooding are included; the effects of these variables were controlled to make the findings more robust. Two of the variables associated with the severity of flooding, duration and depth of floodwater, are found significant, a slightly higher odds of developing anxiety and depression was observed with increased duration of floodwater inside the house premise and slightly higher odds of depression were observed with increased depth of floodwater inside the house. After controlling for the severity of flooding and other secondary stressors, a shorter duration of stay at the current place of residence (less than one year) has the highest impact on anxiety and depression. Displacement and relocations can induce 'relocation stress' (Parker, 1977; Munro *et al.,* 2017). Besides the ones who are displaced are usually the ones

who face severe flooding may be because of their location near the river or near the broken embankment, therefore has had the highest impact. The presence of chronic illness increases the odds of developing PTSD, thus, they have to bear the twin burden of physical and mental morbidity as a result of the stress induced by flooding. Among the four types of 'losses', damage to houses is associated with three of the mental health conditions. Damage to houses is associated with the financial burden of repairing as well as the physical burden of cleaning it; both can take a toll on individuals' mental health. The effects of flooding on mental health are not gender-neutral; it is observed that women have slight but significantly higher odds of developing PTSD and anxiety. The study is carried out in a rural setting where women perform most household chores including taking care of children and cleaning and rearranging houses after flood-related destruction. Previous studies have attributed females' vulnerabilities to inequitable power relations within households apart from biological and physiological differences between genders (Sadia *et al.,* 2016).

This study has numerous limitations. First, the data only includes those family members who were present during the survey. Residents who went to work are potentially excluded from the survey. The second limitation is related to the cross-sectional study design and timing of the survey. While the findings are accessible for a single time point six to seven months after the flood, it is not known how many cases existed prior to the flood and how many developed into chronic cases. Third, floods occur frequently in the study area, which is situated in the Aie River basin. Three flood waves occurred in the year 2021, with the final one arriving in early November. The remaining two waves were less severe and lingered for a shorter period than the initial wave that arrived in August. Poor mental health outcomes can be a cumulative result of multiple waves of flooding. The fourth limitation is related to the baseline differences themselves. A great deal of difference between the control and exposed populations in terms of their income and education levels was observed. The baseline differences could arise because of selective migration from the study area. Outmigration is a long-term strategy of adaptation to flooding in the area. Out of the 255 flood-affected households surveyed, 40 (15.6 per cent) are all-time migrant households where one or more than one individual migrated out at some point in the past; of the 40 households, 27 had at least one member of their household migrate out recently in the year 2021. The number of all-time migrating and recent migrating households is considerably low (10 and 4 per cent, respectively) in the non-flooded areas. A chi-square test of independence was performed to assess the relationship between recent migrations and flood exposure categories. There is a significant relationship between the two variables, x^2 (1, N = 505) = 8.07, p = .005). Migration from flood-affected areas may explain some of the baseline differences in characteristics of the population such as income and education levels, between the flooded and non-flooded villages. The baseline differences were not controlled in the study. Despite its flaws, the study gives valuable evidence from a resource-constrained study area where fluvial floods are recurring in nature.

Conclusion

Floods have significant adverse impacts on mental health in the study area. While Assam is a place of recurrent floods, limited studies address the impacts of flooding on mental health. About six to seven months after the flood, the elevated risks of PTSD, anxiety, and depression among flood-affected participants are two to five times higher compared to the non-flooded ones, and for comorbid PTSD, anxiety, and depression, the risks are 21 times higher, suggesting that mental health implications linger for a long time. It bears repeating that flooding is recurring in nature in the flooded areas and that over one-fourth of flood-affected participants show symptoms of PTSD, more than one-third show symptoms of depression, and nearly half of the flood-affected participants reveal symptoms of anxiety, highlighting the need for attention in planning and risk mitigation, particularly during the recovery phase. One outcome-based indicator of disaster risk

reduction that the SENDAI framework promotes is measurable vulnerability reduction (Raju & Costa, 2018). Incurring loss can reduce resilience and increase vulnerability, more so when such losses are recurring in nature and the onus for rebuilding falls on those affected. While efforts should be made to address vulnerable groups such as females, people with chronic illnesses, and people whose houses were damaged, in the meantime, the provision of community support and psychological first aid, particularly among the displaced, is essential for reducing the mental health effects of flooding. How the burden of mental health is transformed into healthcare-seeking behaviour is not known. Future studies can also deliberate on such issues.

Declarations

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Competing interests. The authors declare that they have no competing interests.

Ethical standard. Participants are all above 18 years of age. All participants were informed about the purpose of the study and made aware of the voluntary participation. Prior consent of participation was taken from the participants and an informed participation consent form was signed. The study was approved by the Institutional Ethical Review Committee at Jawaharlal Nehru University, New Delhi (Ref. No. 2021/PhD Student/275).

References

Ahern, M, Kovats RS, Wilkinson P, Few R and Matthies F (2005) Global health impacts of floods: epidemiologic evidence. *Epidemiolgic Reviews* **27**(1), 36–46. https://doi.org/10.1093/epirev/mxi004

Alderman K, Turner L and Tong S (2013) Assessment of the health impacts of the 2011 summer floods in Brisbane. *Disaster Medicine and Public Health Preparedness* **7**(4), 380–386.

Ali H, Modi P and Mishra V (2019) Increased flood risk in Indian sub-continent under the warming climate. *Weather and Climate Extremes* **25**, 100212. https://doi.org/10.1016/j.wace.2019.100212

Ashok V, Premaranjan KC, Philip Rajkumar R and Nanda Naik B. (2019) Mental Health status of flood-affected adulats in rural Tamil Nadu: a cross sectional study. *CHRISMED Journal of Health and Research* **6**, 97–101.

Bandla S, Nappinnai N and Gopalasamy S (2019) Psychiatric morbidity in December 2015 flood-affected population in Tamil Nadu, India. *International Journal of Social Psychiatry* **65**(4), 338–344. https://doi.org/10.1177/0020764019846166

Cherry K, De Vito AN, Calamia MR, Elliott EM, Yu S, Sampson L, Galea S, Mansoor M, McKneely KJ and Nguyen QP (2021) Disaster stressors and psychological well-being in older adults after a flood. *Psychologu of Aging* **36**(5), 660–666. https://doi.org/10.1037/pag0000602

Cochran WG (1977) Sampling Techniques. John Willy & Sons.

CRED. (2023) *Disasters in numbers 2022*. Centre for Research on the Epidemiology of Disasters. https://cred.be/sites/default/files/2022_EMDAT_report

Dai W, Kaminga AC, Tan H, Wang J, Lai Z, Wu X and Liu A. (2017a) Long-term psychological outcomes of flood survivors of hard-hit areas of the 1998 Dongting Lake flood in China: prevalence and risk factors. *PLos One* **12**(2), e0171557. https://doi.org/10.1371/journal.pone.0171557

Dai W, Kaminga AC, Tan H, Wang J, Lai Z, Wu X, Xiong Y, Deng J and Liu A. (2017b) Comorbidity of post-traumatic stress disorder and anxiety in flood survivors: prevalence and shared risk factors. *Medicine* **96**(36), e7994. https://doi.org/10.1097/MD.0000000000007994

Dai W, Wang J, Kaminga AC, Chen L, Tan H, Lai Z, Deng J and Liu A. (2016). Predictors of recovery from post-traumatic stress disorder after the dongting lake flood in China: A 13-14 year follow-up study. *BMC Psychiatry* **16**(1), 382. https://doi.org/10.1186/s12888-016-1097-x.

Dar KA, Iqbal N, Prakash A and Altaf Paul M. (2018) PTSD and depression in adult survivors of flood fury in Kashmir: the payoffs of social support. *Psychiatry Research* **261** 449–455. https://doi.org/10.1016/j.psychres.2018.01.023

Fernandez A, Black J, Jones M, Wilson L, Salvador-Carulla L, Astell-Burt T and Black D (2015) Flooding and mental health: a systematic mapping review. *PLos One* **10**(4), e0119929. https://doi.org/10.1371/journal.pone.0119929

Fontalba-Navas A, Lucas-Borja ME, Gil-Aguilar V, Arrebola JP, Pena-Andreu JM and Perez J. (2017) Incidence and risk factors for post-traumatic stress disorder in a population affected by a severe flood. *Public Health* **144**, 96–102. https://doi.org/10.1016/j.puhe.2016.12.015

Foudi S, Oses-Eraso N and Galarraga I (2017) The effect of flooding on mental health: Lessons learned for building resilience. *Water Resource Research* **53**(7), 5831–5844. https://doi.org/10.1002/2017WR020435

French cE, Waite TD, Armstrong B, Rubin GJ, English National Study of Flooding and Health Study Group, Beck CR and Oliver I (2019) Impact of repeat flooding on mental health and health-related quality of life: a cross-sectional analysis of the English National Study of Flooding and Health. *BMJ Open* **9**(11), e031562. https://doi.org/10.1136/bmjopen-2019-031562.

Government of Assam. (2022) *District Disaster Management Plan, Bongaigaon District*. Assam State Disaster Management Authority. https://reliefweb.int/report/india/assam-state-bangaigaon-district-disaster-management-plan-2011-2012

Government of India. (1980) *Rashtriya Barh Ayog (National Commission on Floods)* (Volume I). Ministry of Energy and Irrigation (Department of Irrigation).

Government of India. (2019) National Health Action Plan on Climate Change and Mental Health, Ministry of Health and Family Welfare, https://ncdc.mohfw.gov.in/wp-content/uploads/2024/07/2-National-Action-Plan-on-climate-change-and-Mental-Health.pdf

Hetherington E, McDonalad S, Wu M and Tough S. (2018) Risk and protective factors for mental health and community cohesion after the 2013 Calgary flood. *Disaster Medicine and Public Health Preparedness* **12**(4), 470–477. https://doi.org/10.1017/dmp.2017.91

James LE, Welton-Mitchell C, Noel JR and James AS (2020). Integrating mental health and disaster preparedness in intervention: a randomized controlled trial with earthquake and flood-affected communities in Haiti. *Psychological Medicine* **50**, 342–352.

Jose M and Fenn J (2021) Post-traumatic stress disorder and resilience among flood affected farmers of Kerala, India. *International Journal of Community Medicine and Public Health* **8**(4), 1842–1846. https://doi.org/10.18203/2394-6040.ijcmph20211243

JoyJ LK, Ramachandran M and George S (2021) Learned helplessness, psychological wellbeing, and proenvironment care behavior among victims of frequent floods in Kerala. *Journal of Neurosciences Rural Practice* **12**(1), 137–144. https://doi.org/10.1055/s-0040-1721566

Lamond JE, Joseph RD and Proverbs DG. (2015) An exploration of factors affecting the long term psychological impact and deterioration of mental health in flooded households. *Environmental Research* **140**, 325–334.

Lebowitz A, Tachikawa H, Aiba M, Okamoto Y, Takahashi S, Nemoto K and Arai T. (2019) Post-flood social support networks and morbidity in Joso City, Japan. *Psychiatry Research* **271**, 708–714. https://doi.org/10.1016/j.psychres.2018.11.073

Mahmood HN, Ibrahim H, Ismail AA and Neuner F (2022) The mental health of forcibly displaced couples. *Journal of Traumatic Stress* **35**(6), 1598–1607. https://doi.org/10.1002/jts.22862

Man Cheung C, Jalal Sabeena and Ullah Khan Najib. (2014). Posttraumatic stress disorder and psychiatric comorbidity following the 2010 flood in Pakistan: exposure characteristics, cognitive distortions, and emotional suppression. *Psychiatry* **77**(3), 289–304. https://doi.org/10.1521/psyc.2014.77.3.289

Mason V, Andrews H and Upton D. (2010) The psychological impact of exposure to floods. *Psychological Health and Medicine* **15**(1), 61–73. https://doi.org/10.1080/13548500903483478.

Mathew G, Varghese AD, Sabu AM and Joseph A (2021) Screening for post-traumatic stress disorder among adolescents following foodsa comparative study from private and public schools in Kerala, India. *BMC Pediatrics* **21**, 462. https://doi.org/10.1186/s12887-021-02933-4

McMillen C, North C, Mosley M and Smith E (2002) Untangling the psychiatric comorbidity of posttraumatic stress disorder in a sample of flood survivors. *Comprehensive Psychiatry* **43**(6), 478–485.

MN V and Sekar K (2012) Assessment of psychosocial impact of flood on children: indian experience. *Journal of the Indian Academy of Applied Psychology* **39**, 19–22.

Munro A, Kovarts RS, James Rubin G, David Waite T, Bone A, Armstrong B and **the English Ntional Study of Flooding and Health Study Group**. (2017) Effects of evacuation and displacement on the association between flooding and mental health outcomes: A cross-sectional analysis of UK survey data. *The Lancet Planetary Health* **1**(4), e134–e141. https://doi.org/10.1016/S2542-5196(17)30047-5.

Norberg SJ, Toohey AM and Hogan DB. (2021) How do non-catastrophic natural disasters impact middle-aged-to-older persons? Using baseline Canadian longitudinal study on aging data to explore psychological outcomes associated with the 2013 calgary flood. *Canadian Journal on Aging* **41**(2), 184–192. https://doi.org/10.1017/S0714980821000271

Paranjothy S, Gallacher J, Amlot R, James Rubin G, Page L, Baxter T, Wight J, Kirrage D, McNaught R and SR P. (2011) Psychosocial impact of the summer 2007 floods in England. *BMC Public Health* **11**, 145.

Parker G (1977). Cyclone tracy and Darwin Evacuees: on the restoratio of the species. *British Journal of Psychiatry* **130**(June), 548–555.

Patel FM, Oswal RM and Mehta RY (2015) Posttraumatic stress disorders in adult victims of 2006 flood in Surat, Gujarat. *Gujarat Journal of Research in Medical and Dental Science* **3**(4), 303–306. https://doi.org/10.5455/jrmds.20153413

Peek-Asa C, Ramirez M, Young T, Cao Y (2012) Flood-related work disruption and poor health outcomes among university students. *Prehospital and Disaster Medicine* **27**(6), 503–508. doi: 10.1017/S1049023X1200129X

Price M, Szafranski DD, Stolk-Cooke KV and Gros DF (2016) Investigation of an abbreviated 4 and 8 item version of the PTSD Checklist 5. *Psychiatry Research* **239**, 124–130.

Raju E and de Costa K (2018) Governance in the Sendai: a way ahead? *Disaster Prevention and Management: An International Journal* **27**(3), 278–291. https://doi.org/10.1108/DPM-08-2017-0190.

Sadia H, Iqbal MJ, Ahmed J, Ali A, Ahmed A (2016) Gender-sensitive public health risks and vulnerabilities' assessment with reference to floods in Pakistan. *International Journal of Disaster Risk Reduction* **19**, 47–56. https://doi.org/10.1016/j.ijdrr.2016.08.024

Sharpe I and Davison CM (2021) Climate change, climate-related disasters and mental disorder in lowand middle-income countries: a scoping review. *BMJ Open* **11**, e051908. https://doi.org/10.1136/ bmjopen-2021-051908

Srivastava M, Goel D, Semwal J, Gupta R and Dhyani M (2015) Posttraumatic stress disorder symptoms in the population of Uttarkashi, Tehri, and Pauri Garhwal India in reference to Uttarakhand flood - June 2013. *International Journal of Health System and Disaster Management* **3**(5), 37–43.

Stanke C, Murray V, Amlot R, Nurse J and Williams R. (2012) The effects of flooding on mental health: Outcomes and recommendations from a review of the literatures. *PLoS Current* **4**, e4f9f1fa9c3cae. https://doi.org/10.1371/4f9f1fa9c3cae

Tempest EL., Group, E. N. S. on F. and H. S., Carter B, C. R. B. B. and James Rubin G. (2017) Secondary stressors are associated with probable psychological morbidity after flooding: A cross-sectional analysis. *The European Journal of Public Health* **27**(6), 1042–1047. https://doi.org/10.1093/eurpub/ckx182

Thomas JJ, B P, Kulkarni P and MurthyMR N (2021) Exploring the psychiatric symptoms among people residing at flood affected areas of Kodagu district, Karnataka. *Clinical Epidemiology and Global Health* **9**, 245–250. https://doi.org/10.1016/j.cegh.2020.09.006

Tong S (2017) Flooding-related displacement and mental health. *The Lancet Planetary Health* **1**(4), E124–E125. https://doi.org/10.1016/s2542-5196(17)30062-1

Wind TR, Joshi PC, Kleber RJ and Komproe IH. (2013) The impact of recurrent disasters on mental health: a study on seasonal floods in northern India. *Prehospital and Disaster Medicine* **28**(3), 279–285. https://doi.org/10.1017/S1049023X13000290

Woodhall-Melnik J and Grogan C (2019) Perceptions of mental health and wellbeing following residential displacement and damage from the 2018 St. John river flood. *International Journal of Environmental Research and Public Health* **16**,4174.

Yoda T, Yokoyama K, Suzuki H and Hirao T. (2017) Relationship between long-term flooding and serious mental illness after the 2011 Flood in Thailand. *Disaster Medicine and Public Health Preparedness* **11**(3), 300–304. https://doi.org/10.1017/dmp.2016.148

Zhong S, Yang L, Taloo S, Wang Z, Tong S, Sun X, Crompton D, FitzGerald G and Huang C. (2018) The long-term physical and psychological health impacts of flooding: a systematic mapping. *Science of the Total Environment* **625**, 165–194. https://doi.org/10.1016/j.scitotenv.2018.01.041

Appendix Table 1. Association between Mental Health Outcomes and Socio-Demographic Variables and Flood Exposure Categories (Relative Risks And 95% CI. Adjusted ORs are adjusted for all Potential Confounders)

Explanatory variable	Probable PTSD (cases (n) = 151, Sample Size (N) = 866)		Probable anxiety (cases (n) = 260, Sample Size (N) = 866)		Probable depression (cases (n) = 232, Sample size (N) = 866)		Comorbidity (cases (n) = 97, Sample size (N) = 866)	
	Univariate	Adjusted	Univariate	Adjusted	Univariate	Adjusted	Univariate	Adjusted
Exposure to flood: Non-flooded	1	1	1	1	1	1	1	1
Flooded	5.14 (3.30–8.02)**	4.62 (2.63–8.1)**	4.54 (3.28–6.28)**	5.28 (3.38–8.26)**	2.91 (2.15–3.92)**	3.45 (2.24–5.33)**	21.49 (7.90–58.47)**	21.68 (7.38–63.74)**
Age : 18 to 35 years	1	1	1	1	1	1	1	1
36 to 60 years	1.19 (.85–1.68)	1.1 (0.7–1.75)	.98 (.75–1.28)	0.82 (0.54–1.23)	1.08 (.81–1.43)	1.02 (0.68–1.52)	1.14 (.74–1.75)	0.92 (0.53–1.61)
Above 60 years	.86 (.51–1.46)	0.73 (0.35–1.52)	1.71 (.83–1.66)	1.28 (0.7–2.35)	1.11 (.76–1.63)	1.25 (0.69–2.25)	.88 (.46–1.68)	0.86 (0.36–2.05)
Gender: Male	1	1	1	1	1	1	1	1
Female	1.19 (.86–1.64)	1.23 (0.81–1.87)	1.15 (.89–1.47)	1.18 (0.82–1.71)	1.18 (.91–1.53)	1.26 (0.88–1.81)	1.49 (.98–2.26)	1.66 (0.99–2.78)
Marital Status: married	1	1	1	1	1	1	1	1
Unmarried	1.32 (.75–2.34)	1 (0.48–2.09)	1.13 (.75–1.70)	0.7 (0.37–1.33)	1.14 (.74–1.76)	0.68 (0.36–1.3)	1.69 (.79–3.66)	0.43 (0.12–1.54)
Widow and divorce	.78 (.35–1.70)	0.79 (0.38–1.65)	.58 (.32–1.06)	0.89 (0.48–1.64)	.59 (.31–1.11)	0.87 (0.48–1.58)	.36 (.09–1.39)	0.58 (0.22–1.51)
Education: High school pass	1	1	1	1	1	1	1	1
Illiterate	2.61 (1.64–4.16)**	2 (1.08–3.7)*	2.44 (1.69–3.52)*	1.94 (1.13–3.35)*	2.01 (1.37–2.94)**	1.43 (0.84–2.44)	4.42 (2.33–8.39)**	2.78 (1.28–6.05)*
Up to class X	1.52 (.97–2.39)	1.14(0.66–1.96)	1.74 (1.23–2.45)*	1.27 (0.8–2.02)	1.56 (1.10–2.22)*	1.2 (0.77–1.88)	1.98 (1.04–3.76)*	1.25 (0.6–2.6)
Presence of chronic illnesses or long-term health conditions: no	1	1	1	1	1	1	1	1
Yes	3.24 (1.95–5.37)**	2.45 (1.37–4.4)**	2.79 (1.73–4.51)**	1.81 (1.02–3.2)*	1.826 (1.12–2.99)*	1.16 (0.66–2.04)	2.61 (1.45–4.69)**	1.47 (0.74–2.93)
Disease prevalence after flood: no	1	1	1	1	1	1	1	1
Yes	2.08 (1.11–3.91)*	0.92 (0.46–1.85)	2.003 (1.13–3.55)*	0.78 (0.4–1.53)	1.84 (1.02–3.29)*	0.87 (0.44–1.7)	2.04 (.99–4.22)	0.82 (0.36–1.87)
Duration of stay at current place of residence: More than 50 years	1	1	1	1	1	1	1	1

(*Continued*)

Appendix Table 1. (*Continued*)

Explanatory variable	Probable PTSD (cases (n) = 151, Sample Size (N) = 866)		Probable anxiety (cases (n) = 260, Sample Size (N) = 866)		Probable depression (cases (n) = 232, Sample size (N) = 866)		Comorbidity (cases (n) = 97, Sample size (N) = 866)	
	Univariate	Adjusted	Univariate	Adjusted	Univariate	Adjusted	Univariate	Adjusted
Less than 1 year	8.86 (3.52–22.32)**	2.33 (0.84–6.47)	18.67 (6.09–57.20)**	5.51 (1.68–18.08)**	16.54 (5.41–50.60)**	6.41 (1.98–20.72)**	16.61 (6.38–43.19)**	2.86 (1–8.18)*
1–10 years	6.89 (3.63–13.08)**	2.66 (1.29–5.51)**	15.69 (7.70–31.99)**	5.6 (2.57–12.17)**	9.09 (4.75–17.42)**	3.96 (1.94–8.06)**	7.55 (3.68–15.50)**	1.88 (0.84–4.19)
10–50 years	2.64 (1.78–3.92)**	1.17 (0.72–1.89)	3.03 (2.19–4.19)**	1.26 (0.84–1.9)	1.65 (1.18–2.31)**	0.8 (0.53–1.21)	2.80 (1.70–4.60)**	0.81 (0.46–1.44)
Income: fourth quartile								
First quartile	1.55 (.96–2.52)	1.32 (0.77–2.27)	1.87 (1,24–2.82)*	1.69 (1.04–2.73)*	1.62 (1.06–2.46)*	1.35 (0.85–2.15)	1.25 (.72–2.17)	0.96 (0.51–1.81)
Second quartile	1.32 (.77–2.26)	1.29 (0.72–2.33)	1.62 (1.03–2.56)**	1.63 (0.97–2.74)	1.46 (.92–2.31)	1.4 (0.85–2.32)	.74 (.38–1.46)	0.66 (0.31–1.38)
Third quartile	1.04 (.61–1.77)	1.06 (0.59–1.89)	1.56 (1.01–2.403)*	1.62 (0.98–2.63)	1.22 (.78–1.90)	1.15 (0.71–1.88)	.88 (.48–1.62)	0.87 (0.44–1.72)
Cons		0.03 (0.02–0.07)		0.06 (0.03–0.11)		0.1 (0.06–0.18)		0.01 (0–0.02)

Adjusted for age groups, sex, marital status, education level, household income, presence serious disease after flood, presence of chronic illnesses or long-term health conditions, duration of residence at the current place, and flood exposure

***significant at 1 per cent; **significant at 5 per cent; *significant at 10 per cent

Appendix Table 2. Association between Mental Health Outcomes and Socio-Demographic Variables, Severity of Flooding, Status of Early Warning, Status of Displacement, and Various Types of 'Losses' Incurred (Odds Ratio and 95% CI. Adjusted ORs are adjusted for all Potential Confounders)

	aOR (95%)			
Explanatory variables	Probable PTSD (cases (n) = 128, Sample size (N) = 450)	Probable Anxiety (cases (n) = 216, Sample size (N) = 450)	Probable depression (cases (n) = 176, Sample size (N) = 450)	Probable comorbidity (cases (n) = 93, Sample size (N) = 450)
Age: 18 to 35 years	1	1	1	1
36 to 60years	1.03 (0.6–1.77)	0.65 (0.39–1.06)	0.97 (0.58–1.63)	0.8 (0.44–1.45)
More than 60 years	0.57 (0.24–1.38)	1.07 (0.49–2.3)	0.85 (0.38–1.87)	0.77 (0.3–1.96)
Gender: Male	1	1	1	1
Female	1.75 (1.07–2.88)*	1.69 (1.07–2.65)*	1.57 (0.98–2.52)	1.64 (0.95–2.85)
Marital status: married	1	1	1	1
Unmarried	0.56 (0.2–1.54)	0.66 (0.29–1.49)	0.55 (0.22–1.38)	0.36 (0.1–1.35)
Widow and divorce	0.83 (0.34–2.05)	0.8 (0.35–1.82)	0.94 (0.4–2.2)	0.43 (0.14–1.33)
Education: High school pass	1	1	1	1
Illiterate	1.72 (0.83–3.57)	2.09 (1.07–4.1)*	1.89 (0.93–3.82)	2.44 (1.07–5.59)*
Up to class X	1.03 (0.53–1.99)	1.35 (0.76–2.43)	1.37 (0.74–2.54)	1.03 (0.48–2.24)
Presence of chronic illnesses or long-term health conditions: No	1	1	1	1
Yes	2.48 (1.26–4.88)**	1.61 (0.81–3.17)	1.63 (0.82–3.24)	1.55 (0.74–3.24)
Disease prevalence after flood: No	1	1	1	1
Yes	1.2 (0.57–2.55)	0.87 (0.42–1.8)	1.1 (0.53–2.3)	0.93 (0.4–2.17)
Duration of stay in the current place of residence: More than 50 years	1	1	1	1
Less than 1 year	1.89 (0.61–5.9)	4.09 (1.17–14.29)*	5.64 (1.57–20.22)**	2.56 (0.83–7.95)
1 to 10 years	1.96 (0.88–4.4)	3.64 (1.52–8.69)**	3.42 (1.51–7.76)**	1.83 (0.77–4.34)
10 to 50 years	1.02 (0.56–1.87)	0.7 (0.41–1.19)	0.65 (0.37–1.12)	0.94 (0.48–1.85)
Income: Fourth quartile	1	1	1	1
First quartile	1.03 (0.52–2.02)	1.22 (0.66–2.25)	1.07 (0.56–2.05)	1.13 (0.55–2.31)
Second quartile	1.37 (0.71–2.63)	1.12 (0.62–2.04)	1.51 (0.81–2.83)	0.79 (0.38–1.68)
Third quartile	0.85 (0.43–1.69)	1.47 (0.79–2.73)	0.88 (0.45–1.69)	0.84 (0.4–1.78)
Duration of floodwater at the house premise: less than one week	1	1	1	1
More than one week	1.6 (0.96–2.69)	1.69 (1.04–2.75)*	1.9 (1.15–3.12)*	1.58 (0.89–2.81)
Depth of floodwater inside the house : less than 100 cm	1	1	1	1

(*Continued*)

Appendix Table 2. (*Continued*)

Explanatory variables	aOR (95%)			
	Probable PTSD (cases (n) = 128, Sample size (N) = 450)	Probable Anxiety (cases (n) = 216, Sample size (N) = 450)	Probable depression (cases (n) = 176, Sample size (N) = 450)	Probable comorbidity (cases (n) = 93, Sample size (N) = 450)
More than 100 cm	1.68 (0.94–3.01)	1.3 (0.75–2.26)	1.87 (1.07–3.28)*	1.3 (0.68–2.47)
Reliability of the flood warning: Reliable	1	1	1	1
Less reliable	1.19 (0.53–2.68)	0.9 (0.42–1.9)	0.97 (0.44–2.11)	1.02 (0.41–2.53)
Not received warning	0.88 (0.47–1.66)	0.59 (0.34–1.03)	0.69 (0.38–1.25)	0.94 (0.46–1.9)
Status of displacement: not displaced	1	1	1	1
Displaced	1.12 (0.67–1.86)	0.92 (0.57–1.48)	0.79 (0.48–1.3)	0.86 (0.48–1.54)
Crop loss: no	1	1	1	1
Yes	1.31 (0.77–2.2)	0.86 (0.53–1.4)	1.19 (0.72–1.96)	1.75 (0.98–3.12)
Livestock loss: no	1	1	1	1
Yes	1.13 (0.69–1.86)	1.21 (0.78–1.88)	1.06 (0.66–1.69)	0.94 (0.54–1.63)
Workdays loss: no	1	1	1	1
Yes	0.25 (0.05–1.4)	1.1 (0.18–6.89)	0.33 (0.06–1.74)	0.37 (0.05–2.58)
Damage to house: no	1	1	1	1
Yes	2.04 (1.09–3.82)*	1.6 (0.94–2.73)	2.17 (1.22–3.87)**	2.16 (1.07–4.36)*
_cons	0.24 (0.04–1.61)	0.34 (0.05–2.51)	0.45 (0.07–2.79)	0.17 (0.02–1.49)

** Significant at .01 percent; *significant at .05 percent
Source: Calculated by the researcher based on household survey data, February-March 2022

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