Climate-related shocks and other stressors associated with depression and anxiety in Bangladesh: a nationally representative panel study

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Summary

Background Climate change has major implications for common mental disorders including depression and anxiety in vulnerable nations such as Bangladesh. However, knowledge gaps exist around national estimations of depression and anxiety, and the associations between the prevalence of these disorders with climate-related and sociodemographic risk factors. To address these gaps, this study analysed data from a nationally representative panel study in Bangladesh that examined climate-related and sociodemographic correlates of depression and anxiety.

Methods Two rounds of nationally representative household panel data were collected from urban and rural areas between August and September, 2019, and January and February, 2020. Households were selected for inclusion across 150 enumeration areas as the primary sampling units with use of a two-stage stratified random sampling design, and survey instruments were administered to the available adult member of the household. Depression and anxiety were measured with the Patient Health Questionnaire-9 and Generalized Anxiety Disorder-7 scales, respectively, and weighted prevalence estimates were calculated on the basis of the 2011 national population census. Data on temperature and humidity were collected from 43 weather stations and constructed as mean values for the 2-month period preceding each round of the survey. Self-reported exposure to flooding was collected for a 12-month recall period. We applied a weighted population average logistic model on the pooled sample of both surveys to analyse the associations between ambient temperature, humidity, exposure to flooding, seasonality, sociodemographic variables, and three outcome conditions (depression, anxiety, and co-occurring depression and anxiety; at the level of p<0·1). The models accounted for temporal and spatial heterogeneity. Standard errors were clustered at the level of each primary sampling unit.

Findings 3606 individuals were included with 3·5% dropout in the second survey round (pooled sample n=7086; age range 15–90 years; 2898 [40·9%] men and 4188 [59·1%] women). National weighted prevalence estimates were 16·3% (95% CI 14·7–17·8) for depression, 6·0% (4·7–7·3) for anxiety, and 4·8% (3·7–5·9) for co-occurring depression and anxiety. We observed no significant associations between overall seasonality (summer *vs* winter) and the odds of depression (adjusted odds ratio 3·14 [95% CI 0·52–19·13], p=0·22), anxiety (0·16 [0·02–1·41], p=0·10), or co-occurring depression and anxiety (0·13 [0·01–1·49], p=0·10). An increase in mean temperature of 1°C within the 2 months preceding the surveys was associated with increased odds of anxiety (1·21 [1·00–1·47], p=0·046) and increased odds of co-occurring depression and anxiety (1·24 [1·00–1·53], p=0·045), whereas increased temperature was not associated with depression (0·90 [0·77–1·04], p=0·15). An increase in mean humidity of 1 g/m³ was not associated with depression (0·99 [0·96–1·02], p=0·60) or anxiety (1·04 [0·99–1·09], p=0·13), but was associated with co-occurring depression and anxiety (1·06 [1·00–1·12], p=0·064). Exposure to flooding within the 12 months preceding the survey rounds was associated with increased odds of all outcome conditions (depression, 1·31 [1·00–1·70], p=0·047; anxiety, 1·69 [1·21–2·36], p=0·0020; and co-occurring depression and anxiety, 1·87 [1·31–2·68], p=0·0006).

Interpretation Climate-related shocks and other stressors have an important association with the burden of depression and anxiety in Bangladesh. Community-level interventions for common mental disorders need to be developed and assessed for safety, feasibility, and effectiveness in a Bangladeshi context. Further research on climate-related stressors is needed over different timespans and time intervals.

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Research in context

Evidence before this study

We conducted a search on PubMed for articles in English published in peer-reviewed journals between Jan 1, 2010, and June 24, 2020, using the keywords "climate change", "depression", "anxiety", "mental health", and "Bangladesh". Articles on ecological grief, ecological anxiety, or solastalgia were excluded. After screening abstracts and relevant full texts, we identified studies and literature reviews that assessed the correlation between increased ambient temperature and mental health morbidity and mortality in high-income and low-income and middle-income countries. However, no south Asian countries, including Bangladesh, were found to have reported on this association. Climate change modelling studies predict that average temperatures and the occurrence of extreme temperatures and the frequency and intensity of extreme weather events will increase in Bangladesh, which is already highly vulnerable to climate change, with expected negative effects on mental health outcomes. We identified community-based epidemiological studies in Bangladesh with small sample sizes that reported poor mental health outcomes associated with extreme weather-related shocks. However, none of the identified studies provided a nationally representative perspective on the association between mental health outcomes and elevated temperature and humidity and weather shocks, representing crucial gaps in the literature.

Added value of this study

This study is one of the first in Bangladesh and south Asia to establish associations between adverse mental health outcomes and climate-related factors, including elevated temperature, humidity, and weather shocks, such as exposure to flooding. Given the vulnerability of the country and region to climate change impacts, the findings of this study justify further investigation into the links between climate change and mental health, and could help to inform a policy and programmatic response to the issue. The study also provides weighted national prevalence estimations of depression, anxiety, and co-occurring depression and anxiety, which are valuable contributions to the mental health literature for Bangladesh.

Implications of all the available evidence

This study adds to growing literature from low-income, middle-income, and high-income countries that has identified climate-related stressors, such as elevated temperature and humidity and extreme weather shocks, to be significantly associated with adverse mental health outcomes. These associations need to be examined rigorously via longitudinal studies to establish and monitor trends over time for mental health outcomes. Adaptation measures should also be considered for climate-related extreme weather. Such measures will be particularly important for highly vulnerable groups residing in disaster-prone areas affected by the impacts of ongoing and future climate-related crises, and for those residing in urban centres that have unique ecological risk profiles due to temperature and sociodemographic dynamics.

Introduction

In a 2009 *Lancet*–University College London Commission, climate change was described as "potentially the biggest global health threat in the 21st century",[1] with anticipated negative effects on mental health, in addition to physical health consequences. Climate change can directly influence mental health outcomes by affecting the lives of individuals who experience intense heat and extreme weather events including floods, wildfires, cyclones, and hurricanes.[2] Climate change also increases the likelihood of prolonged droughts, food insecurity, loss of habitat, land inundation and salination due to rising sea levels, deforestation, and forced migration, all of which increase the risk of a range of mental health problems, including depression and anxiety.[2]

Major depressive disorder and generalised anxiety disorder are the two most prevalent mental disorders globally, and are a substantial public health concern.[3] In 2017, 4·4% of the world's population were estimated to be affected by depression, and 3·6% by anxiety.[4] In the same year, more than 80% of the burden associated with depression, in terms of years lived with disability, was reported in low-income and middle-income countries (LMICs).[4] Although extensive research has been conducted on the determinants of depression and anxiety globally, extreme weather events related to climate change represent a new constellation of risks for common mental disorders that have not been studied comprehensively, especially in LMIC settings.

Bangladesh, a lower-middle income country in south Asia, was recently ranked by the Global Climate Risk Index as the world's seventh most vulnerable country to climate change (based on the period 1999–2018).[5] Bangladesh is located in the world's largest river delta and frequently experiences extreme flooding and cyclones,[6,7] which are major risk factors for common mental disorders. Estimates from a national survey conducted in 2018–19 (n=9516) by the Bangladesh National Institute of Mental Health (NIMH) indicated a prevalence of 6·7% for depression and 4·5% for anxiety.[8] However, there are several important knowledge gaps in the evidence surrounding common mental disorders and climate change in Bangladesh. In particular, the connection between common mental disorders and increasing ambient temperature, humidity, and extreme weather events needs further examination to inform an evidence-based national response.

The Intergovernmental Panel on Climate Change predicts heatwaves and humid heat stress to increase in

intensity and frequency in south Asia in the coming decades.[9] Bangladesh already experienced a 0·5°C increase in temperature between 1976 and 2019, and temperature is projected to increase by 1·4°C by around 2050.[10] Simulation studies have projected deadly heatwaves for densely populated areas of Bangladesh.[11] Urban centres such as Dhaka and Chattogram are comprised of man-made structures and reduced vegetation, making these areas especially vulnerable due to urban heat island effects.[11] A recent systematic review that included 66 studies from regions worldwide examined the association between elevated temperatures and mental health-related mortality and morbidity.[12] A 1°C increase in temperature was associated with increased risk of morbidity due to mental health problems, including depressive and anxiety disorders. Populations in tropical zones were found to be especially vulnerable. Approximately half the studies (n=28) included in the review were from LMICs, of which the majority (n=17) were from China, and none were from south Asia. Given this backdrop, the lack of research on the association between temperature and mental health outcomes is an important limitation in understanding the full scope of climate-related vulnerability of Bangladeshi populations.

A sparse number of mostly community-based studies have investigated the effects of weather shocks on mental health in Bangladesh. In these studies, extreme weather events were associated with post-traumatic stress disorder, anxiety, depression, and sleep disorders;[13] climate-related mental health effects in disaster zones, especially coastal areas, were greatest among women.[14] Experiencing weather-related shocks (eg, loss of housing, agricultural land, or livestock) was associated with increased strain on the individual, stress, and anxiety.[6] In southeastern hilly zones, psychological effects of climate change included depression, anxiety, suicide, and harmful substance use.[15] Increased stress and mental health problems have also been reported in Bangladesh after extreme flooding.[7] However, these findings require further substantiation as they are limited to select populations and particular regions, and no national study to date has examined the association of climate-related factors with common mental disorders in Bangladesh.

Some evidence has indicated that symptoms of anxiety disorder often co-present with depression or influence its onset.[16] Symptom profiles of common mental disorders in LMIC settings do not necessarily align with disorder classifications as defined by diagnostic systems established in high-income countries.[17] The co-occurrence of mental disorders such as depression and anxiety in LMICs remains a poorly understood topic, and has been cited as a major knowledge gap in the field of global mental health.[18] As climate change-related events can trigger a range of pathological conditions, symptoms, and sequelae, examining comorbid common mental disorders might offer valuable insights.

Accordingly, this study analysed data from a nationally representative panel study in Bangladesh that examined climate-related and sociodemographic correlates of three outcome conditions: depression, anxiety, and co-occurring depression and anxiety.

Methods

Study design and participants

This study analysed panel survey data collected for The World Bank by Data International.[19] The survey was a two-round household-level panel study designed to be nationally representative of Bangladesh, including urban and rural areas. With use of two-stage stratified sampling and a probability proportional to size method, the survey identified 150 enumeration areas as the primary sampling units (PSUs) in the first stage of the selection process across three strata: rural areas, comprising 90 PSUs; Dhaka and Chattogram city corporations, comprising 24 PSUs; and other urban and peri-urban areas, comprising 36 PSUs. Urban areas were defined as city corporations and peri-urban areas as the remaining urban areas. The distribution of the PSUs is presented in the appendix (p 1). The second stage involved a household listing exercise in each of the PSUs to identify households that met the following criteria set a priori: households with women and children younger than 5 years; households with an older population (age ≥66 years); and households with other combinations of these demographics. The households in each PSU were randomly selected from the pool of eligible households based on a ratio of 16:2:2 (rural areas: Dhaka and Chattogram city corporations: other urban and peri-urban areas) to mimic the distribution of the national population census of Bangladesh in 2011. Further details of the sampling methods have been published elsewhere.[19] The first round of the survey, provided to the available primary adult member of the household (aged ≥15 years; either the head of household or their spouse based on self-identification as such), included 3606 individuals between August and September, 2019 (exact dates unavailable), immediately past the peak of summer, characterised by higher temperatures. The second round of the survey was administered to the same individuals between January and February, 2020, during the winter, which typically has cooler temperatures. To encourage participation, the responding households were transferred mobile phone talk-time worth approximately US$2·17 (2019 exchange rates) at completion of the survey. To ensure their continued participation in the panel survey, the enumerators maintained communication with the households through telephonic means each month, in conjunction with a commitment to transfer approximately $2·17 to the household once every 2 months until the next round of the survey for households that maintained contact. The average response rate across the two surveys was 93%. Further details of the questionnaire and survey design, including the sampling strategy, have been published.[19]

See Online for appendix

Ethical approval was obtained from the Bangladesh Medical Research and Council (registration number 240 05 08 2019) before commencement of the survey. All ethical protocols and standards of the Bangladesh Medical Research and Council were adhered to during fieldwork, including the collection of informed consent from participants before the interview.

For the **Washington Group Short Set on Functioning** see https://www.washingtongroup-disability.com/question-sets/wg-short-set-on-functioning-wg-ss/

Procedures

For the purposes of presenting these analyses, we refer to major depressive disorder and generalised anxiety disorder as common mental disorders, while acknowledging that our analyses are not comprehensive of all anxiety disorders or other conditions also categorised under common mental disorders. In the surveys, depression was measured with the Patient Health Questionnaire-9 (PHQ-9), a commonly used depression screening instrument, comprising nine items on a 4-point Likert response scale. The PHQ-9 has been culturally adapted (Cronbach's alpha 0·837) for use in Bengali-speaking populations,[20] and has been widely used in Bangladesh.[14,21] For anxiety, the Generalized Anxiety Disorder-7 (GAD-7) tool was used, which is a seven-item, 4-point, Likert-style anxiety screening scale. The GAD-7 has also been adapted (Cronbach's alpha 0·869) and used in clinical and non-clinical settings in Bangladesh.[21,22] Both the PHQ-9 and GAD-7 have a 2-week recall period. Informed by best practice standards reported previously,[23,24] validations conducted in other south Asian countries,[25] and previous research in Bangladesh, a clinical cutoff score of 10 was used to determine the presence of depression and anxiety for the PHQ-9 and the GAD-7, respectively. A recent meta-analysis (6725 participants from 29 studies) reported that sensitivity (0·88) and specificity (0·85) of the PHQ-9 was maximised at a cutoff score of 10, which was deemed to be relevant for research purposes.[26] This approach to defining depression based on the PHQ-9 has recently gained endorsement for its utility by a *Lancet*–World Psychiatric Association Commission on depression.[27] Regarding GAD-7, a meta-analysis (5223 participants in 11 studies) reported maximised sensitivity (0·83) and specificity (0·84) with the cutoff score of 10.[28] A binary variable was constructed to reflect reports of co-occurrence of depression and anxiety.

For the **Demographic and Health Survey method** see https://dhsprogram.com/topics/wealth-index/Wealth-Index-Construction.cfm

A cascading series of questions first inquired as to whether any member of the household had been physically ill within the 12 months preceding the survey, followed by whether they had visited a doctor for the physical illness or illnesses and had received a medical diagnosis. A subsequent set of questions collected detailed symptoms of physical illnesses in the event the individual had not acquired a medical diagnosis. Physical illnesses were defined as persistent or chronic conditions including chronic fever, chronic respiratory illness, and non-communicable diseases (chronic heart disease; gastric disease or ulcer; high blood pressure; arthritis or rheumatism; skin diseases; diabetes; cancers; kidney diseases; liver diseases; paralysis; ear, nose, and throat problems; and eye problems). Physical disability was determined by the Washington Group Short Set on Functioning.

The survey collected localised daily weather data from 43 weather stations (appendix p 2) of the Bangladesh Meteorological Department. For enumeration areas where a weather station was not available, the closest approximations were provided from the nearest weather station in the same district. The data collected included humidity, measured in grams of moisture per cubic meter (g/m^3), and temperature, measured in °C. The weather data were shared with the study team as mean values per month, constructed from daily average estimations. Subsequently, the exposure variables for analysis were constructed as mean values for the 2-month period preceding each round of the survey. A 2-month mean for temperature and humidity was selected as it aligned most closely with the 2-week recall period of the PHQ-9 and GAD-7 for all survey respondents, as survey administration lasted approximately one month. Exposure to flooding, which increases the risk of adverse mental health outcomes, was self-reported and collected for a 12-month recall period. The exposure was coded into a binary variable and included experiences of surging sea levels, flash floods, excessive rises in ground water levels, and riverbank overflow.

In addition to mental and physical health data, the survey gathered information at the individual, household, and community level. Individual-level and household-level information pertained to demographic composition (age, gender, household size, and head of the household), years of education, and socioeconomic status (asset index, per the Demographic and Health Survey method). Gender categorisation in the survey was binary (male or female), and did not include other gender classifications. We also collected information related to water, sanitation, and hygiene (WASH) measures to calculate WASH index (reflected as quintiles of an index constructed with factors such as accessibility to sanitary facilities, type of water used, and hygiene-oriented behaviour such as handwashing[19]), and information on whether the household experienced any economic shocks in the 12 months preceding the survey. Economic shocks were coded into a binary variable and included threats to agricultural yield, livestock diseases, market dynamics that affect profit margins from agricultural products, physical illness of income-earning household members or physical illness of any household member, and death of a household member. Community-level variables were not included in the present analyses.

Statistical analysis

Weighted prevalence estimates for depression and anxiety were calculated with use of pooled mean prevalence from both rounds of the survey. Population weights were derived with the two-stage stratified

sampling strategy and probability proportional to size method,[19] based on the 2011 national population census. In our main analysis, we assessed the associations between climate-related exposure variables, sociodemographic variables, and the three outcome conditions (depression, anxiety, and co-occurring depression and anxiety). All analyses used the pooled sample from both survey rounds. Correlates were established via generalised estimation equations models, to estimate population-averaged effects. Population-weighted bivariable and multivariable logistic regression models were used to generate adjusted odds ratios (ORs) with 95% CIs. The primary climate-related variables were seasonality (summer *vs* winter; to reflect the two timepoints the survey was administered, and as time controls), flood exposure, temperature (per 1°C increase), and humidity (per 1 g/m³ increase). Individual-level demographic characteristics correlated with outcomes in the models were age (26–40 years, 41–65 years, and ≥66 years *vs* 15–25 years), biological sex (female *vs* male), education (per 1 year increase), and the presence of any individual physical disability or physical illness (chronic and persistent conditions). Household characteristics included in the models were household size (per one additional household member), sex of the head of the household (male *vs* female), location (Dhaka and Chattogram city corporations *vs* other urban areas, rural areas, and peri-urban areas combined), asset index quintile (each of quintiles 2–5 *vs* quintile 1), WASH index (per 1 unit increase), experience of any economic shocks, and presence of any physical illness in the household (as a household-level mental stressor). All models accounted for population sampling weights to ensure representativeness, included major locational variations in geographical distribution to control for spatial heterogeneity, and derived standard errors that were clustered at the PSU level.[19] We describe comparative results from the bivariable and multivariable analysis for the primary climate-related exposure variables. For the control variables, we describe results from the multivariable analysis only, with all bivariable and multivariable data provided in tables. To check for attrition bias between the survey rounds, we conducted independent sample *t*-tests of GAD-7 and PHQ-9 scores.

A prespecified p value of less than 0·1 was considered to indicate statistical significance for all analyses. All analyses were done with Stata (version 16.1).

Role of the funding source

The funder of the study had no role in study design, data collection, data analysis, data interpretation, or writing of the report.

Results

We present results from a sample of 3606 individuals (each observed over two survey rounds, pooled sample n=7086; age range 15–90 years) across rural and urban locations in Bangladesh. In the second survey round, 126 (3·5%) individuals in the original sample did not participate. We conducted independent sample *t*-tests to check for attrition bias and detected no significant difference for the GAD-7 scores (p=0·62) or PHQ-9 scores (p=0·65), comparing participants of the second survey with those who had dropped out. Characteristics of the pooled study sample are presented in table 1. Of the 7086 respondents, 2898 (40·9%) were men and 4188 (59·1%) were women, and 5469 (77·2%) were aged 26–65 years. Respondents had a mean of 4·72 years (SD 4·49) of education.

	Mean (SD) or n (%)
Sex	0·40 (0·49)
Female	4188 (59·1%)
Male	2898 (40·9%)
Age group, years	
15–25	1161 (16·4%)
26–40	3162 (44·6%)
41–65	2307 (32·6%)
≥66	456 (6·4%)
Education, continuous years	4·72 (4·49)
Sex of household head	
Female	687 (9·7%)
Male	6399 (90·3%)
Household size	4·26 (1·64)
Resident of Dhaka or Chattogram	1097 (15·5%)

Table 1: **Demographic characteristics of respondents (pooled sample, n=7086)**

The national weighted prevalence was estimated at 16·3% (95% CI 14·7–17·8) for depression and 6·0% (4·7–7·3) for anxiety. The weighted prevalence of co-occurring depression and anxiety was estimated at 4·8% (3·7–5·9). Further prevalence data according to sex, location, and age are provided in the figure.

We present results from bivariable and multivariable logistic regression analyses for the outcomes of depression (table 2), anxiety (table 3), and co-occurring depression and anxiety (table 4). Considering overall seasonality (ie, summer *vs* winter), although the bivariable analyses identified significantly decreased odds of depression in the summer months, this association lost statistical significance in the multivariable model (adjusted OR 3·14 [95% CI 0·52–19·13], p=0·22). The odds of anxiety were significantly associated with summer in the bivariable analysis (although the 95% CI crossed the null). This association did not persist after adjustment in the multivariable analysis (adjusted OR 0·16 [0·02–1·41], p=0·10). Additionally, we identified no significant association of seasonality with co-occurring depression and anxiety in the bivariable model or multivariable model (adjusted OR 0·13 [0·01–1·49], p=0·10). The bivariable analysis identified significantly elevated odds of depression

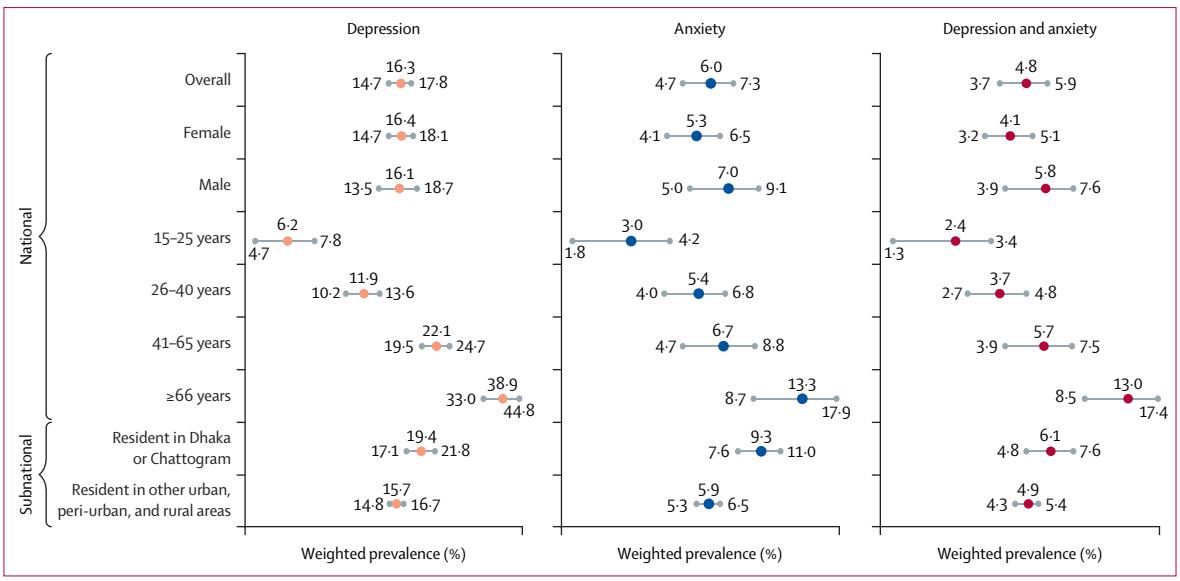

Figure: **National weighted prevalence of depression, anxiety, and co-occurring depression and anxiety in Bangladesh**
Pooled weighted prevalence of depression, anxiety, and co-occurring depression and anxiety representative of individuals across two timepoints (August and September, 2019; and January and February, 2020; n=7086), immediately past the peak of summer and winter seasons. The means and 95% CIs are representative of individuals aged 15 years or older, at the national and subnational levels.

with increased humidity, and reduced odds of depression with increasing temperature; however, these relationships were not significant in the multivariable analysis (per 1 g/m³ increase in mean humidity, adjusted OR 0·99 [0·96–1·02], p=0·60; per 1°C increase in mean temperature, 0·90 [0·77–1·04], p=0·15). For anxiety, no significant relationship with increasing humidity was detected in the bivariable analysis, nor after adjustment in the multivariable analysis (1·04 [0·99–1·09], p=0·13). A 1°C increase in mean temperature was significantly associated with an increase in the odds of anxiety in the multivariable analysis (adjusted OR 1·21 [95% CI 1·00–1·47], p=0·046), which was a stronger association than in the bivariable analysis. For co-occurring depression and anxiety, no significant associations were detected with humidity or temperature in the bivariable analysis. However, in the multivariable analysis, an increase of 1 g/m³ in mean humidity (1·06 [1·00–1·12], p=0·064) and an increase of 1°C in mean temperature (1·24 [1·00–1·53], p=0·045) were significantly associated with the odds of co-occurring depression and anxiety. Exposure to floods within the 12 months preceding the survey rounds was significantly associated with all outcome conditions in the bivariable analysis, and these associations were retained in the multivariable analysis (depression, 1·31 [1·00–1·70], p=0·047; anxiety, 1·69 [1·21–2·36], p=0·0020; co-occurring depression and anxiety, 1·87 [1·31–2·68], p=0·0006).

Regarding the effects of sociodemographic variables (tables 2–4), the odds of depression increased with age in the multivariable analysis. Compared with participants aged 15–25 years, all older age groups showed significantly higher odds of depression, with the oldest adults being the most vulnerable (26–40 years, adjusted OR 1·55 [95% CI 1·14–2·12], p=0·0055; 41–65 years, 2·19 [1·57–3·04], p<0·0001; ≥66 years, 3·98 [2·62–6·04], p<0·0001). We detected a similar trend of increased odds of anxiety for all age groups older than the reference group (26–40 years, 1·64 [1·05–2·56], p=0·031; 41–65 years, 1·55 [0·95–2·52], p=0·082; ≥66 years, 2·64 [1·46–4·78], p=0·0013), although for the 41–65 years group, the 95% CI crossed the null. For co-occurring depression and anxiety, only the group aged 66 years or older had significantly increased odds compared with the 15–25 years group (2·88 [1·51–5·51], p=0·0014). Biological sex had a significant relationship with depression only, with women having higher odds of depression than men (1·29 [1·06–1·57], p=0·011). Similarly, greater time spent in education was significantly associated with reduced odds of depression only (per 1 additional year in education, 0·95 [0·92–0·97], p<0·0001). Individuals with physical disability had significantly higher odds of all outcome conditions than those without a disability (depression, 2·71 [2·18–3·37], p<0·0001; anxiety, 1·80 [1·33–2·43], p=0·0001; co-occurring depression and anxiety, 2·04 [1·43–2·90], p=0·0001). Regarding physical illnesses, the presence of any non-communicable disease significantly increased the odds of depression (1·40 [1·14–1·71], p=0·0014) and anxiety (1·43 [1·01–2·03], p=0·042), but had no effect on the odds of co-occurring depression and anxiety. Chronic fever was significantly associated with increased odds of depression (1·97 [1·20–3·21], p=0·0069), anxiety (2·33 [1·18–4·61], p=0·015), and co-occurring depression and anxiety (although the 95% CI crossed the null; 1·99 [0·93–4·24], p=0·076). Chronic respiratory illnesses were not associated with any of the outcome conditions.

No significant relationships were found between the outcome conditions and the household characteristics of household size or sex of the head of household. Residence in Dhaka and Chattogram was associated with higher odds of depression (2·07 [1·61–2·66], p<0·0001), anxiety (2·14 [1·52–3·02], p<0·0001), and co-occurring depression and anxiety (1·90 [1·28–2·81], p=0·0013) than residence in other urban, peri-urban, and rural areas. We found no significant associations between asset quintile and the outcome conditions. However, experiencing any economic shocks significantly increased the odds of depression (1·76 [1·44–2·14], p<0·0001), anxiety (1·67 [1·30–2·15], p=0·0001), and co-occurring depression and anxiety (1·61 [1·21–2·16], p=0·0013). WASH appeared to be protective, significantly lowering the odds of all outcome conditions (per 1 unit increase in WASH index; depression, 0·89 [0·84–0·94], p<0·0001; anxiety, 0·91 [0·84–0·98], p=0·014; co-occurring depression and anxiety, 0·86 [0·79–0·93], p=0·0004). The presence of any physical illness in the household was associated with increased odds of depression only (1·53 [1·13–2·06], p=0·0056; tables 2–4).

	Bivariable analysis		Multivariable analysis	
	Unadjusted OR (95% CI)	p value	Adjusted OR (95% CI)	p value
Climate exposures				
Summer (*vs* winter)	0·75 (0·63–0·88)	0·0006	3·14 (0·52–19·13)	0·22
Humidity (per 1 g/m^3 increase)	1·04 (1·02–1·05)	<0·0001	0·99 (0·96–1·02)	0·60
Temperature (per 1°C increase)	0·97 (0·96–0·99)	0·0001	0·90 (0·77–1·04)	0·15
Flood exposure	1·34 (1·04–1·72)	0·025	1·31 (1·00–1·70)	0·047
Individual characteristics				
Age group, years (*vs* 15–25)				
26–40	2·05 (1·51–2·79)	<0·0001	1·55 (1·14–2·12)	0·0055
41–65	4·33 (3·23–5·80)	<0·0001	2·19 (1·57–3·04)	<0·0001
≥66	9·68 (6·83–13·72)	<0·0001	3·98 (2·62–6·04)	<0·0001
Female sex (*vs* male)	1·02 (0·86–1·22)	0·81	1·29 (1·06–1·57)	0·011
Years of education (per 1 year increase)	0·88 (0·87–0·90)	<0·0001	0·95 (0·92–0·97)	<0·0001
Physical disability	3·86 (3·20–4·66)	<0·0001	2·71 (2·18–3·37)	<0·0001
Physical illness				
Non-communicable disease	1·98 (1·63–2·40)	<0·0001	1·40 (1·14–1·71)	0·0014
Chronic fever	2·19 (1·38–3·46)	<0·0001	1·97 (1·20–3·21)	0·0069
Chronic respiratory illness	2·14 (1·47–3·13)	0·0001	1·21 (0·81–1·79)	0·35
Household characteristics				
Male head of household (*vs* female)	0·64 (0·49–0·83)	0·0008	0·85 (0·64–1·13)	0·26
Household size (per one additional household member)	0·97 (0·91–1·03)	0·28	1·02 (0·96–1·07)	0·60
Resident in Dhaka and Chattogram (*vs* other urban, peri-urban, and rural areas)	1·28 (1·05–1·56)	0·014	2·07 (1·61–2·66)	<0·0001
Asset index quintile (*vs* quintile 1)				
Quintile 2	0·76 (0·60–0·98)	0·032	0·91 (0·71–1·18)	0·49
Quintile 3	0·65 (0·51–0·83)	0·0005	0·82 (0·64–1·07)	0·14
Quintile 4	0·54 (0·42–0·70)	<0·0001	0·82 (0·62–1·08)	0·16
Quintile 5	0·51 (0·39–0·67)	<0·0001	0·77 (0·55–1·08)	0·13
Any economic shocks	1·66 (1·36–2·03)	<0·0001	1·76 (1·44–2·14)	<0·0001
WASH index (per 1 unit increase)	0·84 (0·80–0·89)	<0·0001	0·89 (0·84–0·94)	<0·0001
Any household physical illness	1·84 (1·33–2·52)	0·0002	1·53 (1·13–2·06)	0·0056

OR=odds ratio. WASH=water, sanitation, and hygiene.

Table 2: **Associations of depression with sociodemographic and climate-related factors (pooled sample, n=7086)**

Discussion

In this nationally representative household panel study in Bangladesh, we identified a weighted prevalence of 16·3% for depression and 6·0% for anxiety. The estimate for depression is higher than what was found by the Bangladesh NIMH in 2018 (6·7%)[8] or in WHO global estimations in 2017 (4·4%).[4] The estimated prevalence of anxiety in this study is similar to that in the Bangladesh NIMH study (4·5%) and in the WHO global estimate (3·6%). The higher prevalence of depression might be due to the inclusion of sub-syndromal states of depression, which are indicative of populations who would benefit from referral to the health system for further assessment. The *Lancet*–World Psychiatric Association Commission on depression[27] recommends a staged model of disease progression for common mental disorders, with specific interventions recommended at each stage of disease severity. Accordingly, such a tiered approach could enable preventive interventions at less advanced stages, and halt or slow progression to more severe outcomes, and would be well suited to address the larger vulnerable population possibly identified in the current study. However, estimates from screening instruments such as the PHQ-9 administered by non-specialists need to be interpreted with caution, and further research that uses diagnostic interviews with trained professionals is necessary in Bangladesh.

To our knowledge this study is one of the first in Bangladesh and south Asia to establish whether ambient temperature, humidity, seasonality, and flood exposure are associated with common mental disorders (depression and anxiety). Although studies in other countries have identified an association between elevated temperature and increased risk of depression,[12] we did not identify such an association in the current study. However, significant relationships between elevated temperature and anxiety and the co-occurrence of depression and anxiety are interesting and potentially impactful findings. Liu and colleagues[12] discussed underlying physiological mechanisms that might contribute to adverse psychological outcomes, including depression and anxiety, and their sequelae following rises in temperature. High temperatures might have a role in affecting the neurotransmitter environment in the brain, in turn affecting mood and cognitive functionality. Additionally, increased temperatures, even for brief periods, have been associated with irritability, psychological distress, and maladaptive

	Bivariable analysis		Multivariable analysis	
	Unadjusted OR	p value	Adjusted OR	p value
Climate exposures				
Summer (*vs* winter)	1·19 (0·97–1·46)	0·099	0·16 (0·02–1·41)	0·10
Humidity (per 1 g/m³ increase)	0·99 (0·97–1·02)	0·66	1·04 (0·99–1·09)	0·13
Temperature (per 1°C increase)	1·02 (1·00–1·03)	0·078	1·21 (1·00–1·47)	0·046
Flood exposure	1·90 (1·38–2·62)	<0·0001	1·69 (1·21–2·36)	0·0020
Individual characteristics				
Age group, years (*vs* 15–25)				
26–40 years	1·90 (1·22–2·93)	0·0041	1·64 (1·05–2·56)	0·031
41–65 years	2·38 (1·58–3·59)	<0·0001	1·55 (0·95–2·52)	0·082
≥66 years	5·03 (2·99–8·47)	<0·0001	2·64 (1·46–4·78)	0·0013
Female sex (*vs* male)	0·76 (0·58–0·98)	0·037	0·88 (0·66–1·18)	0·40
Years of education (per 1 year increase)	0·94 (0·91–0·97)	<0·0001	0·98 (0·95–1·01)	0·21
Physical disability	2·21 (1·69–2·89)	<0·0001	1·80 (1·33–2·43)	0·0001
Physical illness				
Non-communicable disease	1·78 (1·30–2·44)	0·0004	1·43 (1·01–2·03)	0·042
Chronic fever	2·50 (1·28–4·88)	0·0074	2·33 (1·18–4·61)	0·015
Chronic respiratory illness	1·97 (1·11–3·53)	0·022	1·41 (0·79–2·51)	0·24
Household characteristics				
Male head of household (*vs* female)	0·92 (0·63–1·35)	0·67	1·08 (0·70–1·67)	0·74
Household size (per one additional household member)	0·94 (0·87–1·02)	0·17	0·95 (0·88–1·03)	0·21
Resident in Dhaka and Chattogram (*vs* other urban, peri-urban, and rural areas)	1·56 (1·20–2·04)	0·0010	2·14 (1·52–3·02)	<0·0001
Asset index quintile (*vs* quintile 1)				
Quintile 2	0·69 (0·48–1·00)	0·049	0·77 (0·53–1·11)	0·16
Quintile 3	0·70 (0·49–1·00)	0·048	0·84 (0·58–1·21)	0·35
Quintile 4	0·62 (0·42–0·91)	0·015	0·85 (0·56–1·27)	0·42
Quintile 5	0·58 (0·39–0·86)	0·0068	0·78 (0·49–1·25)	0·31
Any economic shocks	1·70 (1·34–2·16)	<0·0001	1·67 (1·30–2·15)	0·0001
WASH index (per 1 unit increase)	0·94 (0·89–1·00)	0·042	0·91 (0·84–0·98)	0·014
Any household physical illness	1·35 (0·85–2·15)	0·21	1·08 (0·70–1·67)	0·73

OR=odds ratio. WASH=water, sanitation, and hygiene.

Table 3: **Associations of anxiety with sociodemographic and climate-related factors (pooled sample, n=7086)**

coping behaviours.[12] Taken together, the evidence suggests that biological components of common mental disorders might be connected to elevated temperatures, which is a growing risk in Bangladesh. In our analysis, increasing humidity was only associated with increased odds of comorbid depression and anxiety, potentially reflecting the occurrence of humid heat stress[11] for vulnerable populations. These findings are alarming considering projections by the Intergovernmental Panel on Climate Change and simulation studies,[9,11] which predict increases in the frequency and intensity of heatwaves and humid heat stress for south Asia, and Bangladesh in particular. The data are especially concerning for low-income populations who typically engage in daily labour and physical activity with considerable exposure to the heat and sun. Experiencing extreme flooding was correlated with depression, anxiety, and their co-occurrence, indicating that coastal populations and those residing in riverine areas are also highly vulnerable to mental health problems.

We did not find conventional indicators of economic status, as measured by an asset ownership index, to be associated with the common mental disorder outcomes. However, vulnerability to depression, anxiety, and their co-occurrence appeared to manifest after experience of household economic shocks. This finding possibly indicates a nuanced mechanism of how poverty functions in affecting mental health outcomes in Bangladesh, in that people might be adjusted mentally to their current socioeconomic status, even those with low income, and vulnerability to developing a mental problem manifests in the experience of an economic shock that disrupts their socioeconomic stability. We also found that residing in urban cities markedly increased the likelihood of depression, anxiety, and their co-occurrence. This observation is notable, as hyper-urbanisation in Bangladesh is leading to an unprecedented rise in the urban population.[29] In recent years, typically economic migrants with low income have often been observed living in informal slum settlements for prolonged periods due to relative socioeconomic immobility.[30] These migrant groups would theoretically be more likely to experience economic shocks as identified in this study, pushing them into further poverty. Slums are also characterised by various forms of social volatility, and as a result, slum residents are disproportionately at increased risk for mental illness.[30] Therefore, residing in urban centres such as Dhaka or Chattogram, mechanisms of poverty, and heat exposure represent a complex network of risk factors that can exacerbate vulnerability to mental illnesses. Addressing these issues will require appropriate measures to prevent and manage common mental disorders in urban areas of Bangladesh. Investigating differential locational and socioeconomic vulnerabilities within the urban space will also be important, as these environments, and the associated risk profiles for mental illness, can vary substantially across neighbourhoods (eg, slums and informal settlements as compared with more affluent areas).

The findings that odds of depression are increased for women, and that older populations have increased vulnerability to poor mental health outcomes, are aligned with global findings.[4] Education was associated with reduced odds of depression, supporting the need to increase access to educational opportunities for Bangladeshi populations.

We observed that having a non-communicable disease or persistent fever increased the odds of depression or anxiety, with persistent fever also associated with co-occurring depression and anxiety. As chronic diseases are projected to increase in Bangladesh,[31] comorbidity with common mental disorders is likely to increase as well. Bangladesh has critically low human resources for mental health care (as of 2021, the number of psychiatrists was 0·16 per 100 000 population; the number

of nurses providing mental health specialty care was 0·4 per 100 000 population; and the number of psychologists was 0·34 per 100 000 population).[32] Therefore, extending mental health training to primary care providers and front-line community health workers will be vital, through the use of task-shifting models, which have demonstrated effectiveness in other south Asian settings.[33] An appropriate next step would be to test task-shifting interventions for common mental disorders to assess safety, feasibility, and effectiveness in a Bangladeshi context.

Finally, our study indicated that having a physical disability substantially increased the odds of all mental disorder outcomes. This finding highlights the importance of thinking about the intersection of mental health, physical health, and climate change, particularly among individuals with disabilities. The connection between the comorbidity of disability and mental illness should be closely examined and elevated as a higher priority for research and health services in Bangladeshi and global policy agendas.

This study had several limitations. Only depression and anxiety were examined as mental health outcomes, and post-traumatic stress disorder or other severe mental disorders were not included. Global research has found associations between increased ambient temperature and post-traumatic stress disorder, severe mental disorders such as schizophrenia, increased hospital admissions for psychiatric emergencies, harmful substance use, and suicide.[12] Further research in Bangladesh is needed to establish the connection between climate-related factors and the full spectrum of mental illnesses. Another limitation is the exclusion of children younger than 15 years and genders other than male and female due to survey-related logistical challenges. The climate variables used in this study are based on data collected from 43 weather stations of the Bangladesh Meteorological Department. For enumeration areas where a weather station was not available, the closest approximation was provided. This approach might have resulted in imprecise measurement of local climate conditions and, consequently, in the estimated effect of climate variables in the analysis. Finally, as this study was implemented within a 1-year period, longer-term studies are needed to evaluate climate variability over broader timeframes. The 1-year period, as well as the time intervals used for climate-related variables, might not have captured the most influential levels of association with common mental disorders. Further research is needed over different time spans and with different time intervals for variables such as high temperature exposure.

In conclusion, this study identified associations between elevated ambient temperature and anxiety, and elevated temperature and the co-occurrence of depression and anxiety, in locations across Bangladesh, which is one of the most vulnerable countries to climate change. Exposure to flooding was also found to be associated with adverse depressive and anxiety outcomes. The study also provides a national perspective of the mental health vulnerabilities among older populations, women, residents of Dhaka and Chattogram, individuals with physical disabilities, those with physical illness, and households experiencing economic shocks. Although mitigation measures for climate change are necessary to buffer against mental health effects, the findings of this study suggest that adaptive actions also need to be taken in response to climate change. The Government of Bangladesh approved a new mental health act in 2018,[32] shifting from a biomedical model to a biopsychosocial, community-based approach to mental illness. Although climate-related contributors to mental health outcomes were not explicitly considered in the act, these should be emphasised in policy and programmatic efforts to

	Bivariable analysis		Multivariable analysis	
	Unadjusted OR	p value	Adjusted OR	p value
Climate exposures				
Summer (*vs* winter)	1·10 (0·86–1·40)	0·45	0·13 (0·01–1·49)	0·10
Humidity (per 1 g/m³ increase)	1·01 (0·98–1·04)	0·53	1·06 (1·00–1·12)	0·064
Temperature (per 1°C increase)	1·01 (0·99–1·03)	0·44	1·24 (1·00–1·53)	0·045
Flood exposure	2·00 (1·39–2·87)	0·0002	1·87 (1·31–2·68)	0·0006
Individual characteristics				
Age group, years (*vs* 15–25)				
26–40	1·63 (0·99–2·68)	0·056	1·36 (0·81–2·29)	0·24
41–65	2·51 (1·58–3·98)	0·0001	1·50 (0·86–2·61)	0·16
≥66	6·15 (3·53–10·73)	<0·0001	2·88 (1·51–5·51)	0·0014
Female sex (*vs* male)	0·71 (0·54–0·95)	0·020	0·87 (0·63–1·19)	0·38
Years of education (per 1 year increase)	0·92 (0·89–0·95)	<0·0001	0·97 (0·93–1·01)	0·12
Physical disability	2·70 (2·00–3·65)	<0·0001	2·04 (1·43–2·90)	0·0001
Physical illness				
Non-communicable disease	1·58 (1·16–2·15)	0·0040	1·18 (0·85–1·65)	0·32
Chronic fever	2·13 (1·00–4·55)	0·050	1·99 (0·93–4·24)	0·076
Chronic respiratory illness	1·99 (1·08–3·64)	0·026	1·27 (0·69–2·32)	0·44
Household characteristics				
Male head of household (*vs* female)	0·79 (0·53–1·18)	0·25	0·89 (0·56–1·41)	0·63
Household size (per one additional household member)	0·95 (0·86–1·04)	0·28	0·97 (0·89–1·06)	0·55
Resident in Dhaka and Chattogram (*vs* other urban, peri-urban, and rural areas)	1·31 (0·96–1·77)	0·085	1·90 (1·28–2·81)	0·0013
Asset index quintile (*vs* quintile 1)				
Quintile 2	0·74 (0·50–1·10)	0·14	0·86 (0·58–1·29)	0·48
Quintile 3	0·67 (0·45–0·98)	0·041	0·89 (0·60–1·31)	0·55
Quintile 4	0·65 (0·43–0·97)	0·036	1·02 (0·67–1·57)	0·92
Quintile 5	0·58 (0·37–0·89)	0·013	0·95 (0·57–1·57)	0·84
Any economic shocks	1·64 (1·24–2·18)	0·0005	1·61 (1·21–2·16)	0·0013
WASH index (per 1 unit increase)	0·89 (0·83–0·95)	0·0009	0·86 (0·79–0·93)	0·0004
Any household physical illness	1·45 (0·88–2·41)	0·15	1·10 (0·69–1·74)	0·70

OR=odds ratio. WASH=water, sanitation, and hygiene.

Table 4: **Associations of co-occurring depression and anxiety with sociodemographic and climate-related factors (pooled sample, n=7086)**

address this growing issue in Bangladesh. Overall, with climate change projected to worsen for Bangladesh, the mental health consequences need to be prioritised and community-based interventions put in place to address this growing challenge.

Contributors

All authors conceived the study. BAK supervised the study. BAK and IM validated the findings and conclusions of the analysis. SSW and WAR designed the methodology, led the investigation, curated data, did the formal analysis with Stata software, and were responsible for data visualisation. IM was responsible for funding acquisition. SSW and WAR accessed and verified the underlying data. SSW wrote the original draft, and BAK, WAR, and IM reviewed and edited the manuscript. All authors had full access to all the data in the study and had final responsibility for the decision to submit for publication.

Declaration of interests

We declare no competing interests.

Data sharing

Anonymised individual data with data labels in Stata format, and the sampling protocol and survey instrument, will be available following publication of this Article. These items will be made available on request to the corresponding author (wraza@worldbank.org); requests for access should include a clearly articulated plan of use for the third party use of data.

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