Adolescent psychological health, temporal discounting, and climate distress under increased flood exposure in Bangladesh: a mixed-methods cross-sectional study

Liza Goldberg, Stephen Luby, Noshin Sayiara Shuchi, Titly Sen, Nazmul Hossen, Gabrielle-Wong Parodi, Erik Jensen, Nicole M Ardoin, Mahbubur Rahman, Farjana Jahan

Summary

Background **Chronic exposure to climate stress disproportionately affects low-income households; however, the psychological health and climate distress levels of climate-vulnerable adolescents in low-resource settings has rarely been explored. We investigated the association between increased flood exposure and adolescent psychological health, climate distress, and temporal discounting (long-term planning capacity).**

Methods **In this cross-sectional, mixed-methods study, we administered surveys to assess symptoms of anxiety and depression, temporal discounting, and climate distress. We surveyed 1200 adolescents aged 15–18 years from low-income households in Dhaka, Bangladesh (a low-flood-risk location) and Barisal, Bangladesh (a high-flood-risk location). We also conducted 16 focus group discussions among adolescents across both regions.**

Findings **Between Aug 7 and Dec 15, 2023, adolescents living under higher flood exposure in Barisal had significantly greater odds of anxiety symptoms (adjusted odds ratio 1·94 [95% CI 1·41–2·65], p<0·0001) and depressive symptoms (3·52 [1·94–6·40], p<0·0001) relative to those under low flood exposure in Dhaka. Adolescents experiencing anxiety symptoms had significantly greater odds of exhibiting temporal discounting (2·00 [1·16–3·45], p=0·013). Our focus group discussions suggest pathways by which cognitive overload during extreme floods contribute to adolescent preferences against long-term flood adaptation planning.**

Interpretation **An increased prevalence of anxiety and depressive symptoms among flood-vulnerable adolescents in low-income settings might be related to temporal discounting behaviour that could threaten their climate change resilience.**

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Introduction

Households living in poverty across low-income and middle-income nations face the growing challenge of adapting to climate change risk in settings of limited economic and infrastructural resources.[1] Climate change-related exposures disproportionately drive socioeconomic consequences, such as livelihood shifts and food insecurity in low-income, marginalised communities, creating potential for the exacerbation of the existing physical and mental health burden of poverty.[2]

Individuals in settings of high climate risk might experience both direct and indirect effects of climate change on their mental health. A growing body of literature has directly linked exposure to extreme weather events to acute stress, trauma, and mental health conditions among survivors.[3] Qualitative studies have established the indirect pathway from climate change stress exposure to socioeconomic consequences, such as livelihood loss and subsequent mental health difficulties.[4] An individual could experience climate anxiety or eco-anxiety (ie, general concern about environmental change) as a chronic, indirect fear over the impacts of climate change and insufficient action to address it.[3,5] Although no widespread consensus on the definition of climate anxiety yet exists, it is generally conceptualised as the range of negative emotions that an individual might feel because of their experience or anticipated experience of climate change-associated losses.[6] Climate anxiety has been established as prevalent among youth aged 16–25 years at varying levels of previous exposure to climate change-related risks: a cross-sectional study found that 60% of adolescents across ten nations at varying stages of development reported feeling "very" or "extremely" worried about climate change.[7] In our study sample, we use the term climate distress to encompass the breadth of negative emotions that adolescents might feel regarding climate change and avoid the pathologisation of adolescent anxiousness about their future, in line with a previous mental health study among climate-vulnerable Tanzanian youth aged 18–23 years.[8]

Despite rapidly growing public and scholarly interest in climate change-associated mental health conditions and

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Department of Earth System Science, Stanford University, Stanford, CA, USA (L Goldberg BSc, G-W Parodi PhD); **Division of Infectious Diseases and Geographic Medicine, Stanford University, Stanford, CA, USA** (Prof S Luby MD); **Woods Institute for the Environment, Stanford University, Stanford, CA, USA** (Prof S Luby MD, G-W Parodi PhD, N M Ardoin PhD); **Environmental Health and WASH, Health Systems and Population Studies Division, International Centre for Diarrheal Disease Research, Bangladesh (icddr,b), Dhaka, Bangladesh** (N Sayiara Shuchi MPH, T Sen MSc, N Hossen MSc, M Rahman MD, F Jahan MD); **Stanford Law School, Stanford, CA, USA** (E Jensen JD); **Department of Environmental Social Sciences, Stanford University, Stanford, CA, USA** (G-W Parodi PhD, N M Ardoin PhD); **Global Health and Migration Unit, Department of Women's and Children's Health, Uppsala University, Sweden** (M Rahman MD)

Correspondence to:
Ms Liza Goldberg, Department of Earth System Science, Stanford University, Stanford, CA 94305, USA
lizagold@stanford.edu

Research in context

Evidence before this study

We searched PubMed and Google Scholar for relevant articles published in English between Jan 1, 2000, and Feb 1, 2025, primarily using combinations of the terms "climate anxiety", "climate change anxiety", "climate change mental health", "temporal discounting", "climate change adaptation", "flood resilience", and "climate change planning". Emerging research has identified positive associations between repeated, long-term extreme weather event exposure and anxiety symptoms and depressive symptoms, but we identified no studies in low-income or lower-middle-income nations that investigated these associations among adolescents. Although studies in low-income, middle-income, and high-income nations have reported a growing prevalence of adolescent climate anxiety, few have investigated this phenomenon among climate-vulnerable adolescents living in low-resource settings. A cross-sectional study in Tanzania found that youth experiencing extreme temperatures were more likely to experience climate distress, and those experiencing food insecurity or water shortages were more likely to suffer from depressive symptoms. Several Bangladesh-based small-scale qualitative studies of the impacts of acute climate change-related events on household mental health outcomes, particularly among women and adolescent girls, were identified. However, we could find no studies that qualitatively sought to identify the pathways from flood exposure to adolescent anxiety symptoms and depressive symptoms. A limited number of studies have investigated the role of poor mental health in temporal discounting among low-income households, but none have explored this relationship in climate-vulnerable settings or among adolescents.

Added value of this study

To our knowledge, this is the first study to examine the relationship between repeated, long-term hazard exposure and adolescent psychological health in a low-income or lower-middle-income nation. We also provide a novel examination of the role of adolescent mental health outcomes in their future planning preferences around climate adaptation. We found that adolescents living under high flood exposure have significantly greater odds of anxiety symptoms and depressive symptoms relative to those under low flood exposure. We also reveal that adolescents suffering from anxiety symptoms are significantly more likely to show temporal discounting preferences. Our focus group discussions identify pathways by which cognitive overload before, during, and after extreme floods contributes to preferences against long-term planning.

Implications of all the available evidence

The higher risk of anxiety symptoms, depressive symptoms, and climate distress among adolescents in Barisal and qualitative pathways between poverty and climate distress indicates that climate-vulnerable adolescents, particularly those in low-income households, might disproportionately experience strong negative emotions about future climate change-related stressors. Intense feelings of cognitive overload and despair might relate to the capacity of adolescents in highly flood-vulnerable settings to prepare for their future under growing climate stress. The design and implementation of immediate community-driven mental health-care interventions for flood-vulnerable adolescents is crucial to promoting their capacity to both cope with intensifying climate stress and plan for their household's future.

climate anxiety, past research has largely ignored their relationship with household attitudes on everyday decision making and long-term climate adaptation in non-Western, Educated, Industrialized, Rich, and Democratic (WEIRD) settings.[9] The cognitive burdens wrought by poverty[10] could be contributing factors to a household's capacity to prepare and respond to climate stress. Notably, the mental strain of financial insecurity has been repeatedly shown to drive temporal discounting behaviour, in which an individual values smaller-scale, shorter-term rewards over longer-term ones.[11] For example, lower wealth levels in Ethiopian[12] and south Indian[13] households have been associated with higher discount rates. Some studies in laboratory settings have also shown associations between general anxiety, depression, and temporal discounting.[14,15] Crucially, temporal discounting could carry exacerbated consequences in climate-vulnerable regions where long-term planning is increasingly essential to resilience.[16]

Residents of Bangladesh are frequently designated as among the most climate vulnerable in the world, given the growing frequency of their exposure to extreme weather events in settings with very limited infrastructural or economic resources for adaptation.[17] A nationally representative study found that extreme temperature, humidity, and flood exposure are positively associated with anxiety and depression among Bangladeshi adults.[18] A small number of mostly qualitative studies have found positive linkages between flood experiences and poor mental health outcomes, particularly among women and girls.[19] However, no studies of psychological health or climate distress in south Asia have been administered among adolescents, and there remains a gap in understanding of the underlying cognitive factors influencing climate adaptation decision making among vulnerable communities.[20] Understanding the mental health needs of adolescents and their temporal discounting patterns is particularly important given that they will emerge as decision makers (approximately at age 18 years) in their households during a time when climate change-related stress is projected to worsen substantially in Bangladesh.[17]

This study takes a first step in deepening this understanding by investigating the association between flood exposure and mental health of Bangladeshi adolescents facing the compounding threat of growing flood risks

and poverty through qualitative inquiry into the potential drivers and quantitative assessment of mental health outcomes. We then sought to understand the association between mental health outcomes and temporal discounting patterns among our sample. We hypothesised that the risk of anxiety symptoms and depressive symptoms might be higher among adolescents under higher flood exposure, and that both mental health anxiety symptoms and depressive symptoms could be associated with increased temporal discounting. We hypothesised that sex, wealth status, and climate change awareness might moderate the association between flood exposure and anxiety symptoms, depressive symptoms, and temporal discounting. These associations could be stronger among female adolescents, individuals with lower wealth status, and those with a higher awareness of climate change.

Methods

Study design and participants

This study used a cross-sectional mixed-methods research approach to provide a standardised measure of mental health and investigate individual perspectives on climate change-associated pathways to these outcomes. Barisal is among Bangladesh's most climate-vulnerable districts due to its high flood exposure, high proportion of low-income households, and limited adaptation infrastructure.[21] Out-migration rates from Barisal to Dhaka are the highest in the country.[22] Dhaka also faces increasing monsoon-driven flood risk and extreme heat exposure, although low-income households in Dhaka are less subject to long-term financial losses than those in Barisal due to Dhaka's strong service-based economy.[23] We collected data from adolescents (aged 15–18 years) who could read and write fluently in English or Bangla in schools across Dhaka and Barisal divisions in central and south-central Bangladesh, randomly selected from lists of student enrolment at each school (figure).

The icddr,b Ethics Review Committee (PR-23074) and the Stanford University Medical Institutional Review Board (70819) approved this study's protocols. We obtained permission from the Bangladesh Directorate of Secondary and Higher Education to conduct our surveys. Participants older than 16 years provided written consent on a provided form in Bangla. Schoolteachers provided written assent on a provided form in Bangla for participants younger than 16 years after discussing the study with each participant, adhering to typical local consent and assent procedures (appendix p 10).

Procedures and outcomes

During Aug 7–25, 2023, semi-structured, single-sex focus group discussions (FGDs) were conducted in Bengali by trained social scientists to adhere to local norms of single-sex environments in schools.[24] We used a common core question set with an additional sensitive question set (eg, those involving gender-based violence) in the all-female FGDs. FGD facilitators matched the sex of the group. FGDs were audio recorded for transcription and analysis.

Surveys were completed between Sept 10 and Dec 15, 2023, and included measures of anxiety symptoms (via the General Anxiety Disorder [GAD]-7 questionnaire), depressive symptoms (via the Patient Health Questionnaire [PHQ]-9 questionnaire), temporal discounting (via the Kirby Questionnaire), and climate distress (via a ten-question climate distress survey) as primary outcomes. Participants reported their sex, wealth status, and climate change literacy in order to assess these variables as prespecified controls. Participants were surveyed immediately after the flood season, which typically occurs between May and September (appendix p 10).

Statistical analysis

We calculated a sample size of 1168 by estimating an effect size of 1·20 greater odds of temporal discounting among adolescents in Barisal relative to those in Dhaka, with α=0·05, β=0·8, and 99% CI, based on previous studies that found 1·5 times greater odds of decreased cognitive function among adult farmers who experienced weather-driven income losses.[25] In all other statistical analyses conducted, we calculated 95% CIs for precision. In this study, we were interested in capturing the views and experiences of adolescents who experienced the worst and mildest of exposure to flooding. Barisal has a higher baseline level of flooding than Dhaka. In Barisal, we limited our pool of schools to recruit from to those located in the top 10% of flooding exposure from 2010–23 (n=40 schools) and in Dhaka to those located in the bottom 10% of flood exposure over the same period (n=20 schools), through mapping flood magnitude and frequency using Sentinel-2 data in Google Earth Engine.[26] We then used a simple random sampling approach to select 12 schools in Barisal and 12 in Dhaka. For the surveys, we used a stratified sampling approach by sex in each school, selecting approximately 50 participants aged 15–18 years per school from school grades 8, 9, and 10, providing a total of 1200 participants (n=600 in Dhaka, n=600 in Barisal).

We used stratified random sampling to select schools in Dhaka and Barisal from our quantitative survey list for conducting FGDs until saturation,[27] which we reached after four schools in Dhaka and four in Barisal. We used a stratified random sampling approach when ten participants of each sex were selected from school grades 8, 9, and 10. Adolescents who completed the surveys were allowed to participate in the FGDs when they were selected. Our FGDs aimed to elucidate the social, cultural, and economic pathways between repeated, long-term exposure to extreme floods with climate distress, temporal discounting, and threats to mental wellbeing.

Regarding the quantitative analysis, the GAD-7, PHQ-9, and Kirby Delay-Discounting tests were standardised with prespecified ranges according to each instrument. We considered GAD-7 and PHQ-9 scores greater than or equal to ten to indicate moderate anxiety (anxiety symptoms) and

See Online for appendix

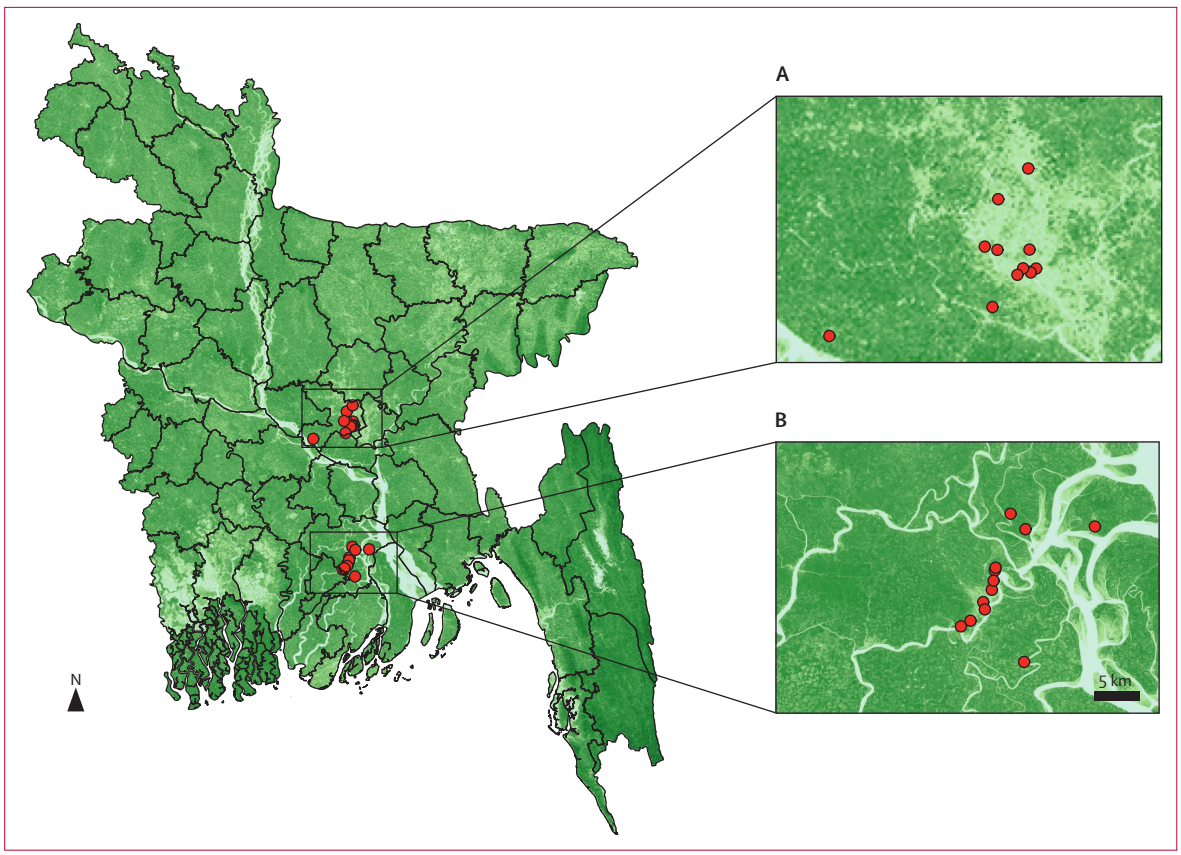

Figure: **Study site locations in Bangladesh**
Study sites at Dhaka (A) and Barisal (B) are shown in red.

moderate depression (depressive symptoms), respectively, according to the literature specifying this cutoff as the most effective optimisation for sensitivity and specificity for both examinations.[28,29] To measure an individual's temporal discounting score using the Kirby Questionnaire, we assigned student selection of the smaller, shorter-term reward with a value of 0 and student selection of the larger, longer-term reward with a value of 1. We summed responses to approximate discounting levels according to typical Kirby Questionnaire evaluation procedures.[30] Due to the absence of established thresholds for adolescents, we conservatively defined discounting as selecting short-term, small-scale preferences in at least 90% of the questions.

We conducted an unadjusted logistic regression to investigate the crude associations between each categorical control (ie, sex, wealth status, and climate change awareness) and each of our three binary primary outcomes (ie, anxiety symptoms, depressive symptoms, and temporal discounting). We conducted an adjusted logistic regression to control for sex, wealth status, and climate change awareness. Each control was predetermined before analysis. Following the analysis method of Caroline Hickman and colleagues,[7] we analysed the proportion difference of adolescents in Dhaka and Barisal who agreed with each individual statement in the ten-question climate distress survey.

Regarding the qualitative analysis, thematic coding of FGDs was completed using a combined deductive and inductive approach according to previously established six-stage robust thematic analysis methods.[31] At stage 1, research team members LG, TS, NH, and NSS met after each FGD in Dhaka and Barisal to discuss impressions from participants' responses and non-verbal cues, generating initial insight into potential inductive codes. TS, NH, and NSS completed translations of the FGD recordings from Bengali to English, discussed the translations, and revisited the Bengali transcripts to resolve clarity issues. At stage 2, three coders from the fields of environmental science and public health coded FGD transcripts with the preset deductive codes recorded in a codebook, determined from literature review taking into consideration the Protection Motivation Theory[32] and Sustainable Livelihoods Framework,[33] and then with the inductive codes. At stage 3, team members frequently met to reach consensus on inductive codes and discuss primary patterns of meaning. At stages 4 and 5, coders recoded transcript summaries until consensus was reached and finalised theme definitions. At stage 6, qualitative findings from the FGDs were triangulated with quantitative survey findings during interpretation and reporting through a narrative-based weaving approach, comparing

qualitative and quantitative findings, then working to understand any differences between the two, depending on field-based knowledge and with consideration of our specified theoretical frameworks.[32–34]

Statistical analysis was completed using Stata version 18.

Role of the funding source

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

Results

1200 female and male adolescents (599 [50%] male and 601 [50%] female; mean age 15·39 [SD 0·63]) were recruited from 12 schools in Dhaka (n=600) and 12 in Barisal (n=600; table 1). We conducted eight FGDs in Dhaka and eight FGDs in Barisal, all of which had approximately ten participants. Mean reported household income in Dhaka was 46096·67 BDT (SD 53466·24) per month (US$376·91 per month), and the mean reported household income in Barisal was 27820·83 BDT (SD 23199·27) per month ($227·48 per month). 325 (55%) adolescents in Barisal were found to be either moderately or severely food insecure, compared with 141 (23%) adolescents in Dhaka (appendix p 5).

509 (85%) adolescents in Barisal and 484 (81%) of adolescents in Dhaka reported being familiar with the concept of climate change (table 2). Adolescents largely reported learning about climate change through school curriculum (ie, books and schoolteachers). Adolescents reported experiencing an average of four floods (SD 1·23) over the past year in Barisal and one flood (SD 0·98) over the past year in Dhaka. 495 (83%) adolescents in Barisal and 45 (8%) adolescents in Dhaka reported a belief that floods have increased in their home region in the last five years. 519 participants in Barisal (87%) and 119 participants in Dhaka (20%) reported a belief that floods are likely to increase in frequency in the future.

Over half of adolescents in each location expressed agreement with nine of ten statements expressing climate distress in the climate distress survey (table 3). However, the proportion of adolescents in Barisal who expressed agreement with climate distress statements was significantly higher than the proportion in Dhaka for seven of the ten statements. Notably, we found a 54 percentage point difference in the proportion of adolescents in Barisal (588 [98%] adolescents) who agreed with the statement "My feelings about climate change negatively affect daily life" relative to those in Dhaka (402 [67%] adolescents), a 49 percentage point difference in agreement with "My family's security will be threatened" (Barisal: 579 [97%] adolescents; Dhaka: 408 [68%] adolescents), and a 47 percentage point difference in agreement with "The things I most value will be destroyed" (Barisal: 557 [93%] adolescents; Dhaka: 345 [58%] adolescents).

	Dhaka (n=600)	Barisal (n=600)
Sex		
Male	300 (50%)	299 (50%)
Female	300 (50%)	301 (50%)
School grade		
8	23 (4%)	59 (10%)
9	552 (92%)	327 (54%)
10	25 (4%)	214 (36%)
Age, years		
15	443 (74%)	374 (62%)
>15	157 (26%)	226 (38%)
Household income, BDT		
<20 000	79 (13%)	281 (47%)
20 000–50 000	391 (65%)	257 (43%)
>50 000	130 (22%)	62 (10%)
Father's occupation*		
Manual worker	38 (6%)	167 (28%)
Businessman	264 (44%)	149 (25%)
Service holder	166 (28%)	182 (30%)
Unemployed	51 (9%)	48 (8%)
Other	81 (14%)	54 (9%)
Mother's employment status		
Not employed	512 (85%)	518 (86%)
Employed	88 (15%)	82 (14%)
Household size		
Small (≤4 people)	286 (48%)	239 (40%)
Large (≥5 people)	314 (52%)	361 (60%)
Wealth status		
Bottom 40%	172 (29%)	311 (52%)
Middle 20%	142 (23%)	105 (18%)
Upper 40%	286 (48%)	184 (30%)
Times moved over lifetime		
1 time	129 (22%)	146 (24%)
2 times	49 (8%)	64 (11%)
3+ times	50 (8%)	35 (6%)
Contributor to most recent household decision to move		
Job	82 (14%)	51 (9%)
Flood	4 (1%)	49 (8%)
Better living conditions	127 (21%)	49 (8%)
Financial challenges	56 (9%)	35 (6%)
Better education	71 (12%)	48 (8%)
Flood survival skill knowledge: swimming		
Knows how to swim (female)	73 (12%)	205 (34%)
Knows how to swim (male)	146 (24%)	254 (42%)
Flood survival skill knowledge: tree climbing		
Knows how to climb trees (female)	42 (7%)	46 (8%)
Knows how to climb trees (male)	106 (18%)	116 (19%)
Times household experienced flood in the past year		
Zero or none	525 (88%)	18 (3%)
1	22 (4%)	45 (8%)
2	23 (4%)	117 (20%)
3	13 (2%)	236 (39%)
4+	17 (3%)	184 (31%)

Data are n (%). *Manual worker: handicraft, farmer, fisherman, mason, and construction labourer; service holder: government employee, private organisation employee, doctor, engineer, and teacher.

Table 1: **Background characteristics of study population**

	Dhaka (n=600)	Barisal (n=600)	Proportion difference (95% CI)
Climate change awareness	484 (81%)	509 (85%)	4 (0 to 8)
Source of awareness			
Books	452 (93%)	489 (96%)	3 (0 to 6)
Schoolteachers	387 (80%)	484 (95%)	15* (11 to 19)
Family members	76 (16%)	45 (8%)	–7* (–11 to –3)
Mass media	157 (32%)	108 (21%)	–14* (–21 to –7)
Social media	129 (22%)	111 (19%)	–5 (–12 to 2)

Data are n (%) or proportion difference (95% CI). *Significant proportion differences.

Table 2: **Climate change awareness rates and sources among study population**

	Dhaka	Barisal	Proportion difference (95% CI)
Humanity is doomed	517 (87%)	560 (93%)	19* (10 to 29)
The future is frightening	458 (76%)	568 (95%)	37* (29 to 45)
I will not have access to the same opportunity that my parents had	325 (54%)	355 (59%)	5 (–1 to 11)
My family's security will be threatened	408 (68%)	579 (97%)	49* (42 to 56)
The things I most value will be destroyed	345 (58%)	557 (93%)	47* (41 to 53)
People have failed to take care of the planet	553 (92%)	569 (95%)	11 (–1 to 22)
I am hesitant to have children	218 (36%)	228 (38%)	2 (–4 to 8)
My previous dreams are not possible anymore	315 (53%)	395 (66%)	18* (8 to 20)
I need to change my career plan to something more stable	388 (65%)	511 (85%)	27* (21 to 36)
My feelings about climate change negatively affect my daily life	402 (67%)	588 (98%)	54* (47 to 60)

Data are n (%) or proportion difference (95% CI). *p<0·05.

Table 3: **Climate distress survey results disaggregated by region**

Our qualitative results reflect the substantial differences in expressed climate distress levels from our survey. In Barisal, adolescents consistently visualised their future as increasingly shaped by growing flood exposure.

> "*We expect that we will have to continue withstanding this for many years to come.*"
>
> *Male adolescent*

Adolescent females in Barisal particularly expressed that their previous educational and occupational goals were now impossible because of flood-driven financial stress:

> "*I used to want to become a teacher myself, but now I believe I will need to get married immediately after school because my father keeps losing his job during the floods.*"
>
> *Female adolescent*

This fear around educational opportunities among females in Barisal sharply contrasted with the relative confidence of those in Dhaka, who did not expect climate stress to threaten their trajectories. Adolescents in Dhaka explained that they "do not personally believe that floods will ever become a major issue" for their households in the future, although many explained that slight increases in flood intensity could be possible over the coming decades.

Of 600 adolescents in each location, 424 (71%) adolescents in Dhaka and 514 (86%) adolescents in Barisal showed anxiety symptoms. After adjusting for sex, wealth status, climate change awareness, and depressive symptoms, the odds of exhibiting anxiety symptoms among adolescents in Barisal were 1·94 times greater than among adolescents in Dhaka (95% CI 1·41–2·65; p<0·0001); table 4. The adjusted odds of exhibiting anxiety symptoms across our study population were 1·77 times greater for females (95% CI 1·31–2·40; p=0·0002); table 4. The adjusted odds of exhibiting anxiety symptoms among adolescents in Dhaka were 2·11 times greater for females than males (95% CI 1·42–3·14; p=0·0002), although there were no significant differences in anxiety symptoms by sex in Barisal (appendix pp 6–9). We observed substantial comorbidity: the odds of exhibiting anxiety symptoms were 12·92 times greater for adolescents with depressive symptoms in Barisal relative to those who did not show depressive symptoms (95% CI 4·17–39·99; p<0·0001) and 8·73 times greater for adolescents with depressive symptoms in Dhaka relative to those who did not show depressive symptoms (95% CI 4·93–15·45; p<0·0001; appendix pp 6–9).

527 (88%) participants in Dhaka and 585 (98%) participants in Barisal showed depressive symptoms (table 4). After adjusting for all controls, the odds of exhibiting depressive symptoms among adolescents in Barisal were 3·52 times greater than those among adolescents in Dhaka (95% CI 1·94–6·40; p<0·0001). After adjustment, female adolescents were less likely than male adolescents to report depressive symptoms (adjusted OR 0·60 [95% CI 0·37–0·98]; p=0·042) across our entire study population. There were no significant differences in depressive symptoms by sex in Dhaka or Barisal. The odds of exhibiting depressive symptoms were 1·86 times greater for adolescents across our entire study population who expressed awareness of climate change (95% CI 1·08–3·18; p=0·024).

Consistent with the quantitative evidence for heightened rates of anxiety and depression symptoms among adolescents experiencing heightened flood exposure, adolescents in Barisal explained that stress during floods influenced household wellbeing beyond the disaster events themselves, often extending throughout the year. Female adolescents expressed that their fathers' job losses often drove significant household conflicts, explaining that their fathers viewed violence as an acceptable stress coping mechanism. Many female adolescents explained that flood frequency increases could magnify their future exposure to violence.

> "*When the floods come, more domestic violence occurs. The floods keep getting worse and worse. So, I may experience even more violence than my mother does.*"
>
> *Female adolescent*

Many female adolescents expressed that they worry frequently about parental job losses resulting in their removal from school and immediate marriage.

"*Sometimes, I worry that my dream will only remain a dream.*"

Female adolescent

Although male adolescents expressed markedly lower anxiety about managing their health and educational opportunities during floods, many emphasised that family conflicts often arose during emergency decision making.

"*If the flood hits during [our specific harvest times], we will have nothing left—no money, no savings, nothing.*"

Male adolescent

By contrast, few adolescents in Dhaka expressed that floods caused family strain, given the floods' relative infrequency. None reported domestic violence during floods, and most adolescents explained that flood-driven income insecurity was "temporary".

"*In other regions, flooding lasts for many days, but here, it is rare and only a few hours.*"

Male adolescent

Households rarely made urgent decisions around emergency management, and reports of intensive family conflict during floods were rare.

41 (7%) participants in Dhaka and 34 (6%) participants in Barisal showed temporal discounting. We found no evidence of significant differences in temporal discounting between locations in either our crude or adjusted logistic regressions (table 4). The adjusted odds of temporal discounting were 2·00 times greater among adolescents with anxiety symptoms across the entire study population (95% CI 1·16–3·45; p=0·013). The unadjusted odds of temporal discounting were 2·34 times greater among adolescents with depressive symptoms across the entire study population (95% CI 1·18–4·62; p=0·014), although we found no evidence of a significant difference in discounting when adjusting for controls. With 93–94% of adolescents exhibiting long-term planning patterns, we had insufficient variation to explore further associations.

Adolescents in both regions expressed some evidence of temporal discounting in FGDs, but clear differences in the pervasiveness of discounting were not observed between those in Dhaka and Barisal. Adolescents in Barisal explained that the cognitive burden of thinking about past flood experiences prevented them and their families from extensively considering future adaptation measures.

"*For low-income households, everyday life is also stressful. Why would we add more stress by thinking about and preparing for these bad events when we are just trying to get through day-to-day?*"

Male adolescent

Many adolescents in the study population expressed a certain fatalism.

	Participants with primary outcome	Unadjusted bivariate		Adjusted multivariate	
		OR (95% CI)	p value	Adjusted OR (95% CI)	p value
Anxiety symptoms					
Area of residence					
Dhaka	424 (71%)	1·0 (ref)			
Barisal	514 (86%)	2·48 (1·86–3·31)	<0·0001	1·94 (1·41–2·65)	<0·0001
Sex					
Male	446 (74%)	1·0 (ref)			
Female	492 (82%)	1·55 (1·17–2·04)	0·002	1·77 (1·31–2·40)	0.0002
Wealth status					
Bottom 40%	393 (81%)	1·0 (ref)			
Middle 20%	188 (76)	0·73 (0·50–1·06)	0·096	0·89 (0·59–1·33)	0·56
Upper 40%	357 (76%)	0·72 (0·53–0·99)	0·042	0·95 (0·67–1·34)	0·76
Awareness about climate change					
No	138 (77%)	1·0 (ref)			
Yes	790 (80%)	1·55 (1·11–2·18)	0·011	1·31 (0·89–1·90)	0·17
Depressive symptoms					
Mild	4 (5%)	1·0 (ref)			
Moderate or above	232 (21%)	11·56 (7·10–18·83)	<0·0001	9·59 (5·77–15·94)	<0·0001
Temporal discounting					
Short term	11 (15%)	1·0 (ref)			
Long term	225 (20%)	2·13 (1·30–3·49)	0·0026	1·97 (1·14–3·38)	0·015
Depressive symptoms					
Area of residence					
Dhaka	527 (88%)	1·0 (ref)			
Barisal	585 (98%)	5·40 (3·06–9·53)	<0·0001	3·52 (1·94–6·40)	<0·0001
Sex					
Male	559 (93%)	1·0 (ref)			
Female	553 (92%)	0·82 (0·53–1·27)	0·39	0·60 (0·37–0·98)	0·042
Wealth status					
Bottom 40%	459 (95%)	1·0 (ref)			
Middle 20%	226 (91%)	0·56 (0·31–1·03)	0·063	0·71 (0·36–1·38)	0·31
Upper 40%	427 (91%)	0·52 (0·31–0·87)	0·013	0·63 (0·36–1·12)	0·11
Awareness about climate change					
No	165 (92%)	1·0 (ref)			
Yes	932 (94%)	2·29 (1·42–3·70)	0·0007	1·86 (1·08–3·18)	0·024
Anxiety symptoms					
Mild	199 (76%)	1·0 (ref)			
Moderate or above	913 (97%)	11·56 (7·10–18·83)	<0·0001	9·89 (5·93–16·50)	<0·0001
Temporal discounting					
Short term	64 (85%)	1·0 (ref)			
Long term	1048 (93%)	2·34 (1·18–4·62)	0·014	1·44 (0·66–3·15)	0·36
Temporal discounting					
Area of residence					
Dhaka	41 (7%)	1·0 (ref)			
Barisal	34 (6%)	1·22 (0·76–1·95)	0·40	1·10 (0·66–1·81)	0·72
Sex					
Male	31 (5%)	1·0 (ref)			
Female	44 (7%)	0·69 (0·43–1·11)	0·13	0·66 (0·41–1·07)	0·091
Wealth status					
Bottom 40%	35 (7%)	1·0 (ref)			
Middle 20%	13 (5%)	1·41 (0·73–2·71)	0·31	1·54 (0·79–3·00)	0·21
Upper 40%	27 (6%)	1·28 (0·76–2·15)	0·35	1·38 (0·81–2·36)	0·24

(Table 4 continues on next page)

	Participants with primary outcome	Unadjusted bivariate		Adjusted multivariate	
		OR (95% CI)	p value	Adjusted OR (95% CI)	p value
(Continued from previous page)					
Awareness about climate change					
No	14 (8%)	1·0 (ref)			
Yes	60 (6%)	1·21 (0·68–2·18)	0·52	1·06 (0·58–1·93)	0·84
Anxiety symptoms					
Mild	27 (10%)	1·0 (ref)			
Moderate or above	48 (5%)	2·13 (1·30–3·49)	0·0026	2·00 (1·16–3·45)	0·013
Depressive symptoms					
Mild	11 (13%)	1·0 (ref)			
Moderate or above	64 (6%)	2·34 (1·18–4·62)	0·014	1·62 (0·76–3·44)	0·21

OR=odds ratio. Patient Health Questionnaire-9 depressive symptom cutoffs were defined as follows: 5 (mild), 10 (moderate), 15 (moderately severe), and 20 (severe). A participant was classified as showing depressive symptoms when they scored above the moderate threshold. General Anxiety Disorder-7 anxiety symptom cutoffs were defined as follows: 5 (mild), 10 (moderate), and 15 (severe). A participant was classified as showing anxiety symptoms when they scored above the moderate threshold. A participant was classified as showing temporal discounting when they scored less than or equal to a score of 13 on the 27-point Kirby Discounting scale. Adjusted ORs indicate adjustment for all other controls in the model.

Table 4: **Crude and adjusted logistic regression analysis of primary outcomes (anxiety symptoms, depressive symptoms, and temporal discounting) in Barisal and Dhaka, Bangladesh**

> *"This kind of life we have resigned ourselves to living. I don't see how things can change, and it is unrealistic to expect that we personally can."*
>
> *Male adolescent*

They believed that long-term considerations of a challenging future were unnecessary given their family's already-high stress levels. Despite affirming that their households expected worsening floods, adolescents explained that their parents rarely allocated savings, preferring to implement smaller-scale infrastructural adaptations, if anything. Some families raised their houses on stilts several inches yearly or repeatedly rebuilt the home in the same location, but most households preferred not to make the financial investment of changing housing materials or moving a farther distance from the river. Financial inability was compounded by a reported reluctance of heads of household to move from ancestral lands unless absolutely necessary. In Dhaka, adolescents rarely reported any considerations of flood-related preparations in their household.

Discussion

This mixed-methods cross-sectional study revealed notably higher rates of anxiety symptoms, depression symptoms, and climate distress among adolescents in Barisal relative to those in Dhaka. The higher rate of climate distress among adolescents in Barisal and qualitative pathways between poverty and climate distress indicates that climate-vulnerable adolescents, particularly those in low-income households, might disproportionately experience strong negative emotions about future climate change-related stressors. Our FGDs provide evidence that intense feelings of cognitive overload and despair might limit the capacity of adolescents in highly flood-vulnerable settings to prepare for their future under growing climate stress.

Our climate distress survey and qualitative results indicated that intense fear about the personal impacts of climate change was pervasive in both Barisal and Dhaka, but substantially higher in Barisal. In Barisal, adolescents agreed with nearly all statements at rates consistently around 10% higher than the global population surveyed by Hickman and colleagues,[7] indicating that climate distress might be higher among individuals who have personally experienced greater climate change-related exposures. Our evidence for a positive association between exposure to high flood risk and climate distress is inconsistent with the results of a cross-sectional study in Tanzania that did not find differences in climate distress levels among those under different levels of climate risk, with the exception of youth working in extreme temperatures.[8] However, climate change distress has been widely linked to direct exposure to climate change-related threats in other non-WEIRD nations.[35]

We did not observe a significant difference in temporal discounting levels between adolescents in Dhaka and Barisal, contrasting with a large literature demonstrating that people living in income insecurity are more likely to discount future payoffs than individuals with more income stability.[10,12,13] It is possible that differences in temporal discounting in ultra-low-resource environments might not emerge until adulthood. It is also possible that the Kirby Questionnaire could have been a suboptimal instrument for this study population because it required participants to make financial comparisons that they might not have been accustomed to. Alternatively, the disproportionate mental health vulnerabilities of adolescents in Barisal might not be sufficiently associated with temporal discounting to result in significant observable differences between regions.

Although we did not observe quantitative differences in discounting between regions, we found strong evidence for an association between anxiety symptoms and temporal discounting and some evidence for an association between depressive symptoms and temporal discounting. Thus, psychological health might be an important contributor to adolescent preferences towards valuing long-term rewards, providing evidence that previous laboratory-based studies[14] that found associations of temporal discounting and psychological health might also apply in low-income field settings. Our conclusions about temporal discounting largely originate from our FGDs, which provided examples of apparent temporal discounting in both regions. In Barisal, adolescents preferred short-term planning over long-term consideration of climate change-related consequences despite their overwhelming consensus that climate change would have severe impacts on their family's security. Likewise, although many adolescents in Dhaka still recognised climate-related losses to be likely in the future, they overwhelmingly felt that long-term planning for these uncertainties was unnecessary given that they perceived the future threat as inadequately severe.

This study also provides empirical and qualitative evidence for the stronger association between flooding and anxiety symptoms among female adolescents during floods and throughout the personal recovery process. The higher anxiety levels among female adolescents and their concerns about household stress and domestic violence during floods align with a growing body of research illustrating that women and girls in settings of gender inequality consistently face greater physical and mental health risks during disasters, underscoring the need for gender-sensitive climate resilience intervention development.[36,37]

A primary strength of this study is its mixed-methods design. Our quantitative surveys enabled the assessment of standardised psychological health metrics, whereas our FGDs enabled us to explore relationships with key factors, such as flooding adaptation infrastructure and local gender norms. Importantly, our mental health investigations in an adolescent study population provide a novel window into the perspectives of climate-vulnerable youth, whose decision-making preferences are rarely assessed.

A primary limitation of this study is that differences in our quantitative outcomes between our Dhaka and Barisal samples cannot solely be attributed to climate change-related stress exposure in Barisal, and instead might be confounded by other differences between the two regions. However, participants revealed in the FGDs that flood-related losses were either a primary cause or significant aggravator of their stress levels and grief year-round. The timing of the survey might have affected students' responses, where they might have exhibited higher or lower levels of anxiety and depression symptoms or temporal discounting based on their recent experience. Surveying adolescents at different times of year, perhaps right before or during flood season, might yield deeper insights into how seasonality could relate to responses.

Our study focused only on a subset of adolescents enrolled in school in Dhaka and Barisal and so is not representative of the psychological health of all adolescents in settings of varying flood exposure across Bangladesh. However, school enrolment among both male and female adolescents is high nationwide, and the level of economic development and flood frequency in Dhaka and Barisal are fairly typical of many moderate and high-flood-risk regions, respectively, across the country.

Future studies should investigate how climate distress, anxiety symptoms, depressive symptoms, and temporal discounting in climate-vulnerable settings vary across the life course, with particular attention to the age or life event (eg, marriage) in which these experiences could emerge. Determining the influence of climate change-driven migration on adolescent psychological health and temporal discounting, particularly for women and girls, could also provide guide resilience-building measures in high displacement settings such as Bangladesh. Tailoring mental health interventions to the adolescent experience in climate-vulnerable settings could have a crucial role in decreasing the potential for temporal discounting patterns to emerge during adulthood. Investigating and targeting identified upstream determinants such as income insecurity that adolescents identified as contributors to their climate distress, psychological stress, and temporal discounting might offer a potential avenue towards mitigating these challenges.

In conclusion, this study establishes the urgency of an emerging psychological health crisis among adolescents in climate change-vulnerable settings with resource limitations. We find that these psychological stressors might not only impact the daily wellbeing of these climate change-vulnerable youths; indeed, they might threaten their capacity to plan a long-term future for their households under a rapidly changing landscape.

Contributors

This study was conceptualised by LG, SL, EJ, G-WP, NMA, and FJ. Instruments were developed and fieldwork was completed by LG, NSS, TS, NH, FJ, and MR. Focus group translation was completed by NSS, TS, and NH. Data analysis was completed by LG, NSS, TS, and NH. Manuscript writing was led by LG, with extensive input from all authors. All authors had access to the data and have seen and approved the final text. LG was principally responsible for the decision to submit the manuscript for publication with extensive input from all authors.

Declaration of interests

We declare no competing interests.

Data sharing

Data analysed for this study are not publicly available but can become available, subject to approval of the Stanford University Medical Institutional Review Board and the icddr,b Ethics Review Board. All other analytical files, including data management documentation, software scripts, log files, and outputs, are available on request from the corresponding author.

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