Cureus
Part of SPRINGER NATURE

Open Access Original Article

Association of Household Food Insecurity With Nutritional Status, Depressive Symptoms, and Anxiety Among School-Going Adolescents in Northern Bangladesh: A Cross-Sectional Study

Irin Hossain [1], Shahria Sattar [1], Afsana Nazneen [1], Lamiya Tasnim Niloy [1], Md Ibrahim R. Rume [2], Tarikul Gazi [1], Md Sunyet A. Chowdhury [3], Nahin N. Nasa [4], Md Ziaul Islam [5]

1. Department of Occupational and Environmental Health, National Institute of Preventive and Social Medicine, Dhaka, BGD 2. Department of Virology, Institute of Epidemiology, Disease Control and Research (IEDCR), Dhaka, BGD 3. Department of Epidemiology and Public Health, Bangladesh Hypertension Control Initiative (BHCI), National Heart Foundation and Research Institute, Dhaka, BGD 4. Department of Global Health, Institute for Global Health and Development, Queen Margaret University, Edinburgh, GBR 5. Department of Community Medicine, National Institute of Preventive and Social Medicine, Dhaka, BGD

Corresponding author: Irin Hossain, irin.hossain@gmail.com

Review began 11/15/2026
Review ended 11/17/2026
Published 11/22/2026

© Copyright 2026
Hossain et al. This is an open access article distributed under the terms of the Creative Commons Attribution License CC-BY 4.0., which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.

DOI: 10.7759/cureus.120105

Abstract

Background: Inadequate household food access may affect adolescent growth and psychological well-being. Evidence examining these outcomes together among school-going adolescents in northern Bangladesh remains limited. This study aimed to assess the association of household food insecurity with nutritional status, depressive symptoms, and anxiety among these adolescents.

Methods: A cross-sectional study was conducted from January to June 2026 among 1,472 school-going adolescents aged 12-16 years (enrolled in classes 9 and 10). Using a stratified multistage cluster sampling procedure, two northern divisions, four districts, and eight upazilas were selected, with one secondary school from each upazila. Food insecurity was measured using the Household Food Insecurity Access Scale (HFIAS), nutritional status was measured using BMI-for-age Z-scores (BAZ) from measured height and weight, and depressive and anxiety symptoms were assessed using the Patient Health Questionnaire-9 (PHQ-9) and the Generalized Anxiety Disorder-7 (GAD-7). Chi-squared tests and cluster-adjusted regression were applied.

Results: Household food insecurity affected 214 households (14.5%): 130 (8.8%) mildly, 40 (2.7%) moderately, and 44 (3%) severely food insecure. Thinness affected 99 adolescents (46.3%) from food-insecure households, compared with 199 (15.8%) from food-secure households. Depressive symptoms affected 45 adolescents (21%) from food-insecure households, compared with 137 (10.9%) from food-secure households. Anxiety symptoms affected 18 adolescents (8.4%) from food-insecure households, compared with 51 (4.1%) from food-secure households. BAZ was lower among adolescents from mildly (B=−0.680), moderately (B=−1.268), and severely food-insecure households (B=−1.554) than among food-secure adolescents. Moderate and severe food insecurity had higher odds of depressive symptoms (AOR 4.73 and 3.73) and anxiety symptoms (AOR 4.78 and 7.03). Older adolescents (B=−0.556) and adolescents who came from lower-income (B=−0.724) or middle-income families (B=−0.255) had lower BAZ, whereas female adolescents had higher BAZ (B=0.247). Food insecurity was associated with family income ($p<0.001$), father's education ($p=0.011$), mother's education ($p=0.043$), and division ($p=0.029$).

Conclusion: Household food insecurity was associated with lower BAZ and higher odds of depressive and anxiety symptoms among school-going adolescents. Schools should screen for food insecurity, assess thin students individually, provide feeding support, offer depression and anxiety screening with counselling for students from food-insecure households and their parents, and provide life-skills training to support self-reliance.

Categories: Psychology, Nutrition, Epidemiology/Public Health
Keywords: adolescents, anxiety, depressive symptoms, household food insecurity, nutritional status

Introduction

Household food insecurity is a public health concern characterized by limited or uncertain access to sufficient, safe, and nutritious food [1]. Approximately 2.1 billion people worldwide experienced moderate or severe food insecurity in 2025, representing 25.8% of the global population; the corresponding prevalence in Asia was 20.3% [1]. Moderate or severe food insecurity affected 21.91% of households in Bangladesh in 2023, with prevalence reaching 29.98% in Rangpur and 25.01% in Rajshahi. The prevalence was 24.12% in rural households and 20.77% in urban households [2]. Food insecurity in Bangladesh has been associated with household income, socioeconomic position, dietary diversity, and other demographic

characteristics [3,4]. Recent research has also documented food insecurity among rural adolescents and children and adolescents living in urban slums in Bangladesh [4,5].

Adolescence is a critical period of physical growth and development, and adequate nutrition during this period is essential for healthy maturation [6]. Household food insecurity may compromise nutritional status by restricting food quantity, dietary diversity, and access to nutrient-rich foods. These conditions may contribute to thinness and other forms of undernutrition, although food insecurity may also coexist with overweight and obesity. A systematic review and meta-analysis reported associations between food insecurity and undernutrition-related outcomes among children and adolescents [6]. Research from South Asia has documented persistent nutritional inequalities among school-age children and adolescents [7]. Studies in Bangladesh have reported nutritional problems among school-going children and adolescents, including differences associated with socioeconomic circumstances and household food access [3-5]. Earlier research has also linked childhood undernutrition with socioeconomic disadvantage in Bangladesh [4].

Household food insecurity may also be associated with psychological distress [8]. Uncertainty about food availability, concerns over household resources, restricted dietary choices, and experiences of hunger may contribute to persistent stress and emotional strain. A systematic review and meta-analysis found associations between food insecurity and poorer mental health, including depression and stress [8]. A recent adolescent study also reported higher risks of depression, anxiety, and stress among food-insecure participants [9]. Research involving parents and children has similarly examined associations between food insecurity and mental health outcomes [10]. A nationwide study in Bangladesh found that food insecurity was associated with depression among adolescent boys and girls [11]. Depression and anxiety symptoms have also been documented among school-going adolescents in Bangladesh [12].

Northern Bangladesh merits specific investigation because household food access and livelihoods may be affected by flooding, river erosion, drought, and seasonal employment [2]. Such conditions can disrupt income and agricultural activities, while limited financial resources may restrict access to diverse and nutritious foods. Evidence from Bangladesh demonstrates substantial regional and socioeconomic variation in food insecurity [2,4]. Although studies have examined food insecurity, nutritional outcomes, and adolescent mental health separately, evidence jointly examining these dimensions among school-going adolescents in northern Bangladesh remains limited. Furthermore, findings from different populations and settings may not fully represent the relationships between household food insecurity, nutritional status, and psychological symptoms in this population.

This study aimed to examine the association of household food insecurity with nutritional status (BMI-for-age Z-scores (BAZ)), depressive symptoms, and anxiety symptoms among school-going adolescents in selected areas of northern Bangladesh. It also assessed the prevalence of household food insecurity and its sociodemographic determinants. By examining these nutritional and psychological outcomes concurrently, the study sought to generate region-specific evidence to inform school-based nutrition and mental health programs in northern Bangladesh.

Materials And Methods

Study design, setting, and participants

A cross-sectional study was conducted from January to June 2026 to examine the association of household food insecurity with nutritional status, depressive symptoms, and anxiety symptoms among school-going adolescents aged 12-16 years in selected areas of northern Bangladesh.

The study area covered selected secondary schools across eight upazilas in four districts of the Rajshahi and Rangpur divisions of northern Bangladesh. These two divisions were chosen because they represent diverse socioeconomic conditions, experience seasonal food insecurity, and differ in access to household resources, which makes them relevant settings for studying household food insecurity and its relationship with the nutritional status of school-aged children.

Rajshahi division was represented by Rajshahi and Natore districts. The selected upazilas in Rajshahi district were Rajshahi Sadar and Puthia, where Loknath High School and Shaheed Nader Ali Girls School and College served as study sites. Natore Sadar and Naldanga upazilas were included from Natore district, with data collected from Collectorate Public School and College and Madhnagar High School.

Rangpur division was represented by Rangpur and Dinajpur districts. Rangpur Sadar and Gangachara upazilas were selected from Rangpur district, and data were collected from Cantonment Public School and College and Dhantala R.U. High School and College. Nawabganj and Birampur upazilas were included from Dinajpur district, with Nandanpur High School and Birampur Pilot High School serving as the study sites.

Adolescents aged 12-16 years enrolled in classes 9 or 10 who were willing to participate, had written consent from a parent or guardian, and gave their own assent were eligible for inclusion. Students with a diagnosed chronic illness, such as a congenital disorder, chronic kidney disease, or thalassemia, or fever at the time of data collection were excluded.

Sample size

The sample size was calculated using an expected prevalence of moderate-to-severe household food insecurity of 31% in Bangladesh, as reported by the Food and Agriculture Organization [13] and used by Mondal et al. [14]. To ensure data sufficiency, the calculation considered an expected prevalence of 31%, an absolute precision of ±10%, and a design effect of 2. The sample size was calculated using the formula $n = [Z^2 \times P \times (1 - P)/d^2] \times DEFF$, where P=0.31, (1−P)=0.69, d=0.10, and DEFF=2. The calculated sample size was 165.2, which was adjusted for a 10% non-response rate, resulting in 183.6 participants. Accordingly, a target of 184 students per school was set, yielding a total target sample of 1,472 students across eight schools.

Sampling technique

A stratified multistage cluster sampling technique was employed. Rajshahi and Rangpur divisions were purposively selected based on their high regional food insecurity prevalence (25.01% and 29.98%, respectively) [2]. Two districts were randomly selected from each division, followed by the random selection of two upazilas from each district using the lottery method. Subsequently, one secondary school was randomly selected from each of the eight upazilas using lists obtained from the respective education offices. Finally, students from classes 9 and 10 were selected through simple random sampling using school registers, with proportional allocation by class and sex. An equal number of students (184) were recruited from each school, resulting in a total sample of 1,472 participants.

Variables of interest

Exposure Variable

Household Food Insecurity Access Scale (HFIAS): Household food insecurity was assessed using the unmodified nine-item HFIAS, developed by USAID's Food and Nutrition Technical Assistance (FANTA) III Project [15]. This experiential scale has been widely used in low- and middle-income countries, including Bangladesh [16,17]. Each item assessed household food insecurity experiences during the previous four weeks and was scored from 0 (never) to 3 (often), based on the frequency of occurrence. Item scores were summed to obtain a total score ranging from 0 to 27, with higher scores indicating greater food insecurity. Households were categorized using established score-based cut-offs applied in Bangladeshi studies [17] as food secure (0-1), mildly food insecure (2-7), moderately food insecure (8-14), or severely food insecure (15-27), ensuring comparability with national evidence. This approach differs from the standard FANTA Household Food Insecurity Access Prevalence (HFIAP) response-pattern classification algorithm.

Outcome Variables

Nutritional status (anthropometric measurement): A standardized checklist was used to record anthropometric measurements. Standing height was measured to the nearest 0.1 cm using a portable stadiometer (Seca 213, Hamburg, Germany) placed on a flat, level surface, and body weight was measured to the nearest 0.1 kg using a calibrated digital weighing scale (Seca 874, Hamburg, Germany) zeroed before each measurement, with participants wearing light clothing and no shoes. Each measurement was taken twice by trained field officers; if the two readings differed by >0.5 cm for height or >0.2 kg for weight, a third measurement was obtained, and the mean of the two closest readings was used for analysis. Body mass index (BMI) was calculated as weight in kilograms divided by height in metres squared (kg/m^2). BAZ were calculated using the WHO 2007 Growth Reference for children and adolescents aged 5-19 years with WHO AnthroPlus software (Geneva, Switzerland). Exact dates of birth were verified from official school admission registers and parental records so that exact age in completed months could be entered into WHO AnthroPlus software for precise Z-score computation, and sex was recorded as male or female. Nutritional status was classified as severe thinness (BAZ <−3 SD), thinness (BAZ ⩾−3 to <−2 SD), normal weight (BAZ ⩾−2 to ⩽+1 SD), overweight (BAZ >+1 to ⩽+2 SD), and obesity (BAZ >+2 SD) [18].

Depressive symptoms (Patient Health Questionnaire-9 (PHQ-9)): Depressive symptoms were assessed using the Bangla version of the nine-item PHQ-9, which assesses the frequency of depressive symptoms over the preceding two weeks [19]. The instrument has previously been used among school-going adolescents in Bangladesh [12,20]. The nine items cover core symptoms of depression, including mood, energy, appetite, sleep, concentration, psychomotor changes, and thoughts related to self-worth. Each item was scored on a four-point scale (not at all=0, several days=1, more than half the days=2, nearly every day=3), giving a total score of 0-27. Scores were grouped as minimal or no depressive symptoms (0-4), mild (5-9), moderate (10-14), moderately severe (15-19), or severe (20-27).

Anxiety symptoms (Generalized Anxiety Disorder-7 (GAD-7)): Anxiety symptoms were assessed using the GAD-7 scale, covering symptoms experienced over the previous two weeks, including excessive worry, nervousness, restlessness, irritability, and difficulty relaxing [21]. Each of the seven items was scored on the same four-point scale as the PHQ-9, giving a total score of 0-21. Scores were grouped as minimal (0-4), mild (5-9), moderate (10-14), or severe (15-21).

Covariates

Sociodemographic characteristics: Sociodemographic information was collected on age, sex, and class; religion; family type (nuclear or joint); household size and number of children; parental education and occupation; monthly household income; housing condition, including type of house and sanitation facilities; and ownership of assets and land. These variables were chosen based on Bangladeshi literature that identifies household socioeconomic status, parental education and occupation, and asset ownership as key determinants of household food insecurity and childhood malnutrition [3,4]. The use of possession-based indicators, such as ownership of land, a radio, a television, or a refrigerator, as proxies for socioeconomic status is supported by community-based studies among Bangladeshi children [4].

Data collection procedure

Validated Bangla versions of the HFIAS, PHQ-9, and GAD-7 underwent independent forward-backward translation verification by bilingual public health experts to prevent semantic drift prior to field deployment. The questionnaire and procedures were pre-tested before the main data collection on about 20 students in each of eight schools outside the main study areas but with similar sociodemographic settings, with particular attention to whether participants understood the HFIAS, PHQ-9, and GAD-7 items and to the time needed to complete the questionnaire. Based on the pre-test, ambiguous wording was simplified, culturally inappropriate terms were revised, and the question order was adjusted for clarity.

Data were collected through structured, face-to-face interviews conducted by trained public health research officers in quiet, private rooms within the schools. Interviewers provided clarification when necessary. Household-level information, including food security, was obtained from parents or guardians through scheduled school meetings or direct communication. Confidentiality was maintained throughout data collection to encourage accurate responses.

Anthropometric measurements were taken using standardized equipment and procedures, with each measurement taken twice and the average recorded.

Students with moderate-to-severe depressive or anxiety symptoms (PHQ-9 ⩾10 or GAD-7 ⩾10), or who endorsed item 9 of the PHQ-9, were identified for further attention. Their parents or guardians were confidentially informed and advised to arrange counselling with physicians. The names of affected students were also confidentially communicated to the respective Upazila Health and Family Planning Officer (UH&FPO) and district Senior Health Education Officer under the Directorate General of Health Services (DGHS) to facilitate follow-up and access to mental health services.

Data management and analysis

Data were managed and analysed using IBM SPSS Statistics for Windows, Version 27.0 (IBM Corp., Armonk, New York, United States). Continuous variables were summarized using means and standard deviations (SD) or medians and ranges, as appropriate, while categorical variables were presented as frequencies and percentages. Age was categorized into young adolescents (12-14 years) and older adolescents (15-16 years), adapting the WHO's age-group classification of 10-14 and 15-19 years to the age range represented in the study population [22]. Monthly family income was categorized into three groups, namely, <15,000 BDT, 15,000-30,000 BDT, and >30,000 BDT, following categories used in a comparable study of food insecurity among rural Bangladeshi adolescents [4]. Household size was dichotomized as small (⩽4 members) and large (⩾5 members), while the number of siblings was categorized as 0, 1-2, and >2 [16].

Unadjusted Pearson's chi-squared tests were used to explore bivariate associations of household food insecurity and sociodemographic characteristics with nutritional status, whereas all primary inferential conclusions were derived from cluster-adjusted multivariable regression models, and multiple linear regression was used to examine the association between household food insecurity and BAZ. PHQ-9 and GAD-7 scores were dichotomized at a cut-off of ⩾10 to define depressive and anxiety symptoms, respectively, following previous studies [12,20]. Univariable and multivariable binary logistic regression analyses were performed to identify factors associated with depressive and anxiety symptoms. Results were presented as crude odds ratios (CORs) and adjusted odds ratios (AORs), with 95% confidence intervals (CIs).

Internal consistency was assessed using Cronbach's alpha (α), which was 0.908 for the HFIAS, 0.704 for the PHQ-9, and 0.733 for the GAD-7. Multicollinearity was assessed using the variance inflation factor (VIF) and tolerance; all variables met the prespecified thresholds (VIF: 1.01-3.67; tolerance: 0.27-0.99). Model goodness-of-fit was assessed using the Hosmer-Lemeshow test, which indicated adequate calibration for both the depressive symptoms ($p=0.782$) and anxiety symptoms ($p=0.789$) models. A p-value of <0.05 was considered statistically significant.

No data were missing, so all 1,472 participants were included in each analysis, and PHQ-9 and GAD-7 scores ⩾10 were considered screen-positive symptoms rather than a clinical diagnosis. To account for clustering of students within the eight schools, cluster-robust (CR2) standard errors were used for linear regression and generalized estimating equations with the Mancl-DeRouen correction for logistic regression, with 95% CIs

(including design-adjusted CIs for prevalence). Because inference with a small number of clusters (G=8 schools) reduces degrees of freedom and can widen confidence intervals despite Bell-McCaffrey (CR2) and Mancl-DeRouen small-sample corrections, school-level intraclass correlation coefficients (ICC) were examined. Furthermore, because the relatively low number of screen-positive anxiety cases (n=69) across 19 model parameters yielded a low events-per-variable ratio (EPV≈3.6), Firth's penalized likelihood logistic regression was conducted as a sensitivity analysis to guard against sparse-data bias.

Ethical considerations

The study was approved by the Institutional Review Board of the National Institute of Preventive and Social Medicine (NIPSOM) (approval number: NIPSOM/IRB/2026/12).

Funding

This research was funded by the Institute of Public Health Nutrition (IPHN) for the fiscal year 2025-2026.

Results

Sociodemographic characteristics

The sociodemographic and household characteristics of the participants are presented in Table *1*. The mean age was 14.05±1.23 years, and 916 participants (62.2%) were young adolescents (12-14 years). Males comprised 756 (51.4%) and females 716 (48.6%), and 764 (51.9%) were students of class 10. Most participants were Muslim (1,325; 90%) and lived in nuclear families (889; 60.4%). Participants were equally distributed between the Rajshahi and Rangpur divisions (736 each; 50%) and across the four districts (368 each; 25%). Fathers most commonly had secondary education (599; 40.7%), whereas 234 mothers (15.9%) were illiterate. Most mothers were housewives (874; 59.4%). The mean monthly family income was 27,130±14,699 BDT, and 827 families (56.2%) belonged to the middle-income category. Semi-pucca houses were the most common type of dwelling (615; 41.8%). Television was the most commonly owned household item (1,029; 69.9%), and 211 participants (14.3%) earned money alongside their studies.

Variables	Category	n (%)
Age (years) (mean±SD: 14.05±1.23)	Young adolescent (12-14 years)	916 (62.2%)
	Older adolescent (15-16 years)	556 (37.8%)
Sex	Male	756 (51.4%)
	Female	716 (48.6%)
Class	9	708 (48.1%)
	10	764 (51.9%)
Religion	Islam	1,325 (90%)
	Hinduism	147 (10%)
Division	Rajshahi	736 (50%)
	Rangpur	736 (50%)
District	Rajshahi	368 (25%)
	Natore	368 (25%)
	Rangpur	368 (25%)
	Dinajpur	368 (25%)
Type of family	Nuclear	889 (60.4%)
	Joint	583 (39.6%)
Number of family members	≤4 members	802 (54.5%)
	≥5 members	670 (45.5%)
Number of siblings	None	224 (15.2%)
	1-2	809 (55%)
	More than 2	439 (29.8%)

Head of family	Father	1,209 (82.1%)
	Mother	140 (9.5%)
	Grandparent	86 (5.8%)
	Others	37 (2.5%)
Father's education	Illiterate	81 (5.5%)
	Primary	117 (7.9%)
	Secondary	599 (40.7%)
	Higher secondary	305 (20.7%)
	Graduate and above	370 (25.1%)
Mother's education	Illiterate	234 (15.9%)
	Primary	408 (27.7%)
	Secondary	470 (31.9%)
	Higher secondary	251 (17.1%)
	Graduate and above	109 (7.4%)
Father's occupation	Service holder (government/private)	329 (22.4%)
	Business	283 (19.2%)
	Farmer	288 (19.6%)
	Day laborer	222 (15.1%)
	Others	350 (23.8%)
Mother's occupation	Service holder (government/private)	193 (13.1%)
	Housewife	874 (59.4%)
	Others	405 (27.5%)
Monthly family income (BDT) (mean±SD: 27,130±14,699)	Lower (<15,000 BDT)	234 (15.9%)
	Middle (15,000-30,000 BDT)	827 (56.2%)
	Upper (>30,000 BDT)	411 (27.9%)
Type of house	Katcha	366 (24.9%)
	Semi-pucca	615 (41.8%)
	Pucca	491 (33.4%)
Owns residential land	Yes	879 (59.7%)
	No	593 (40.3%)
Owns agricultural land	Yes	682 (46.3%)
	No	790 (53.7%)
Household possessions*	Radio	321 (21.8%)
	Television	1,029 (69.9%)
	Refrigerator	621 (42.2%)
Earns alongside studies	Yes	211 (14.3%)
	No	1,261 (85.7%)

TABLE 1: Sociodemographic and household characteristics of the participants (N=1,472)

Descriptive frequencies; no inferential test was applied. Percentages are column percentages.

*Multiple responses

SD: standard deviation; BDT: Bangladeshi taka; katcha: non-durable house; semi-pucca: partly durable house; pucca: durable house

Household food insecurity

The household food insecurity categories of male and female participants are presented in Figure *1*. Most households were food secure (1,258; 85.5%). Mild food insecurity was found in 130 households (8.8%), moderate food insecurity in 40 (2.7%), and severe food insecurity in 44 (3%). Overall, 214 households (14.5%; design-adjusted 95% CI 11.6-18.1) experienced some level of food insecurity, and 84 (5.7%; 95% CI 3.7-8.6) experienced moderate or severe food insecurity. The mean HFIAS score was 1.30±3.47, with a median of 0 (IQR 0-1). Food insecurity was found in 116 males (15.3%) and 98 females (13.7%). According to the HFIAS items, worry that the household would not have enough food was the most frequently reported condition, reported by 400 participants (27.2%); details are presented in Appendix A.

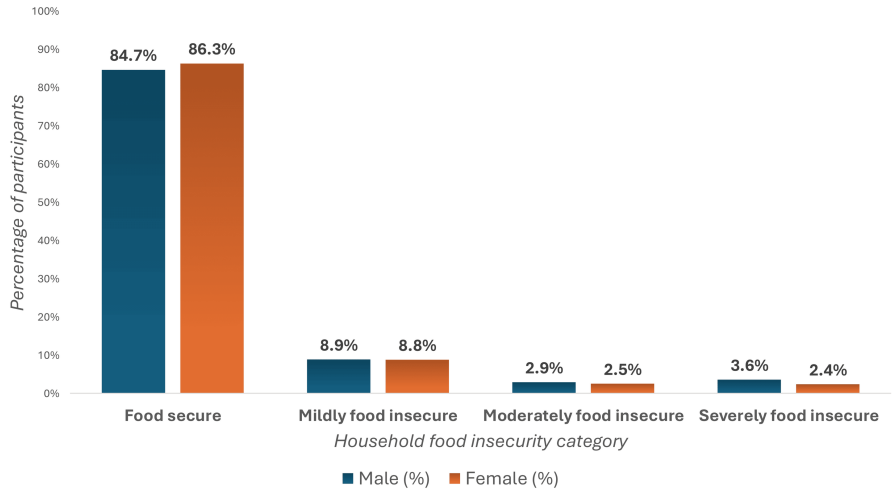

FIGURE 1: Household food insecurity category of participants by sex (N=1,472)

Blue bars represent male participants, and orange bars represent female participants. Percentages indicate the proportion of male and female participants within each household food insecurity category.

Nutritional status

The nutritional status of male and female participants is presented in Figure *2*. Normal nutritional status was observed in 939 participants (63.8%). Thinness was present in 298 participants (20.2%; design-adjusted 95% CI 17.9-22.8), including 130 with severe thinness (8.8%) and 168 with thinness (11.4%). Overweight or obesity was present in 235 participants (16%; 95% CI 13.6-18.6), including 193 who were overweight (13.1%) and 42 who were obese (2.9%). The mean BMI was 18.86±3.58 kg/m^2, and the mean BAZ was −0.64±1.57. Normal nutritional status was more frequent among females (513 of 716; 71.6%) than among males (426 of 756; 56.3%), and thinness was present in 199 males (26.3%) compared with 99 females (13.8%).

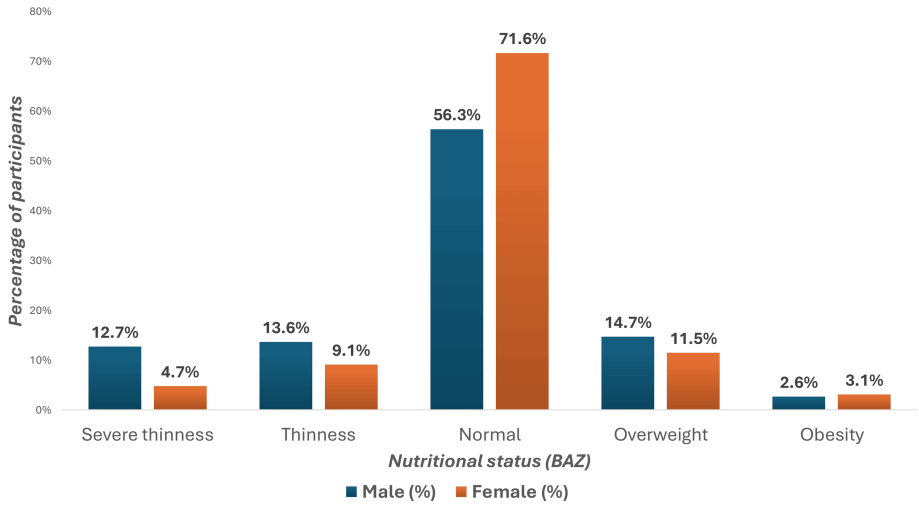

FIGURE 2: Nutritional status of participants by gender based on BAZ (N=1,472)

Blue bars represent male participants, and orange bars represent female participants. Nutritional status was classified according to BAZ. Percentages indicate the distribution of nutritional status categories by sex.

BAZ: BMI-for-age Z-score

Nutritional status differed significantly by household food insecurity (χ^2=126.54; p<0.001), as presented in Table 2. Thinness rose with the severity of food insecurity, from 199 food-secure participants (15.8%) to 50 mildly food-insecure (38.5%), 19 moderately food-insecure (47.5%), and 30 severely food-insecure participants (68.2%). Overweight or obesity was more common among food-secure participants (220; 17.5%) than among food-insecure participants (10/130, 7.7%; 2/40, 5%; and 3/44, 6.8%). Age category (χ^2=31.07; p<0.001), sex (χ^2=43.67; p<0.001), and monthly family income (χ^2=85.18; p<0.001) were also significantly associated with nutritional status. Thinness was more common among older adolescents (141 of 556; 25.4%) than young adolescents (157 of 916; 17.1%), among males (26.3%) than females (13.8%), and among participants from lower-income families (97 of 234; 41.5%) than upper-income families (58 of 411; 14.1%). The remaining characteristics showed no significant association with nutritional status.

Variables	Category	Thinness n (%)	Normal n (%)	Overweight/obesity n (%)	Total	χ^2	P-value
Household food insecurity	Food secure	199 (15.8%)	839 (66.7%)	220 (17.5%)	1258	126.54	<0.001*
	Mildly food insecure	50 (38.5%)	70 (53.8%)	10 (7.7%)	130		
	Moderately food insecure	19 (47.5%)	19 (47.5%)	2 (5%)	40		
	Severely food insecure	30 (68.2%)	11 (25%)	3 (6.8%)	44		
Age category	Young adolescent (12-14 years)	157 (17.1%)	580 (63.3%)	179 (19.5%)	916	31.07	<0.001*
	Older adolescent (15-16 years)	141 (25.4%)	359 (64.6%)	56 (10.1%)	556		
Sex	Male	199 (26.3%)	426 (56.3%)	131 (17.3%)	756	43.67	<0.001*
	Female	99 (13.8%)	513 (71.6%)	104 (14.5%)	716		
Class	9	145 (20.5%)	445 (62.9%)	118 (16.7%)	708	0.65	0.724
	10	153 (20%)	494 (64.7%)	117 (15.3%)	764		
Religion	Islam	272 (20.5%)	846 (63.8%)	207 (15.6%)	1325	1.51	0.471
	Hinduism	26 (17.7%)	93 (63.3%)	28 (19%)	147		
Division	Rajshahi	156 (21.2%)	464 (63%)	116 (15.8%)	736	0.82	0.662

	Rangpur	142 (19.3%)	475 (64.5%)	119 (16.2%)	736		
Type of family	Nuclear	176 (19.8%)	565 (63.6%)	148 (16.6%)	889	0.9	0.638
	Joint	122 (20.9%)	374 (64.2%)	87 (14.9%)	583		
Number of family members	≤4 members	176 (21.9%)	499 (62.2%)	127 (15.8%)	802	3.22	0.200
	≥5 members	122 (18.2%)	440 (65.7%)	108 (16.1%)	670		
Father's education	Illiterate	15 (18.5%)	53 (65.4%)	13 (16%)	81	2.65	0.954
	Primary	29 (24.8%)	69 (59%)	19 (16.2%)	117		
	Secondary	121 (20.2%)	378 (63.1%)	100 (16.7%)	599		
	Higher secondary	61 (20%)	196 (64.3%)	48 (15.7%)	305		
	Graduate and above	72 (19.5%)	243 (65.7%)	55 (14.9%)	370		
Mother's education	Illiterate	54 (23.1%)	139 (59.4%)	41 (17.5%)	234	8.68	0.370
	Primary	89 (21.8%)	253 (62%)	66 (16.2%)	408		
	Secondary	94 (20%)	301 (64%)	75 (16%)	470		
	Higher secondary	48 (19.1%)	168 (66.9%)	35 (13.9%)	251		
	Graduate and above	13 (11.9%)	78 (71.6%)	18 (16.5%)	109		
Father's occupation	Service holder	68 (20.7%)	225 (68.4%)	36 (10.9%)	329	13.98	0.082
	Business	48 (17%)	183 (64.7%)	52 (18.4%)	283		
	Farmer	66 (22.9%)	170 (59%)	52 (18.1%)	288		
	Day laborer	44 (19.8%)	135 (60.8%)	43 (19.4%)	222		
	Others	72 (20.6%)	226 (64.6%)	52 (14.9%)	350		
Mother's occupation	Service holder	45 (23.3%)	116 (60.1%)	32 (16.6%)	193	2.04	0.728
	Housewife	177 (20.3%)	561 (64.2%)	136 (15.6%)	874		
	Others	76 (18.8%)	262 (64.7%)	67 (16.5%)	405		
Monthly family income	Lower (<15,000 BDT)	97 (41.5%)	119 (50.9%)	18 (7.7%)	234	85.18	<0.001*
	Middle (15,000-30,000 BDT)	143 (17.3%)	550 (66.5%)	134 (16.2%)	827		
	Upper (>30,000 BDT)	58 (14.1%)	270 (65.7%)	83 (20.2%)	411		
Type of house	Katcha	82 (22.4%)	227 (62%)	57 (15.6%)	366	2.7	0.609
	Semi-pucca	126 (20.5%)	387 (62.9%)	102 (16.6%)	615		
	Pucca	90 (18.3%)	325 (66.2%)	76 (15.5%)	491		

TABLE 2: Association of household food insecurity and sociodemographic characteristics with nutritional status (N=1,472)

Pearson χ^2 test; row percentages. Thinness includes severe thinness (BAZ <−3 SD) and thinness (BAZ ≥−3 to <−2 SD); normal is BAZ ≥−2 to ≤+1 SD; overweight/obesity includes overweight (BAZ >+1 to ≤+2 SD) and obesity (BAZ >+2 SD).

*p<0.05

n: number of participants; BAZ: BMI-for-age Z-score; SD: standard deviation; BDT: Bangladeshi taka; χ^2: chi-square

The cluster-adjusted multiple linear regression of household food insecurity with BAZ is presented in Table 3. Household food insecurity remained significantly and inversely associated with BAZ after adjustment for sociodemographic characteristics and school clustering, and the reduction in BAZ grew with the severity of food insecurity. Compared with participants from food-secure households, BAZ was lower by 0.680 units in

mildly food-insecure (95% CI −1.033 to −0.327; p=0.003), 1.268 units in moderately food-insecure (95% CI −1.836 to −0.700; p=0.001), and 1.554 units in severely food-insecure households (95% CI −3.040 to −0.069; p=0.043). Older adolescents (B=−0.556; p<0.001) and participants from lower-income (B=−0.724; p<0.001) and middle-income families (B=−0.255; p=0.004) also had significantly lower BAZ, whereas female participants (B=0.247; p=0.017), participants whose fathers had secondary education (B=0.239; p=0.018), and participants from Rangpur division (B=0.105; p=0.033) had significantly higher BAZ. Severe food insecurity (β=−0.169), lower income (β=−0.169), and older age (β=−0.172) showed the strongest associations. The model explained 14.6% of the variance in BAZ (adjusted R^2=0.135; F=13.04; p<0.001). All VIF values were below 5 (1.01-3.67), indicating no multicollinearity, and the intraclass correlation was <0.001.

Variables	Category	B	SE	β	95% CI for B	P-value	VIF
Household food insecurity	Mildly food insecure	−0.68	0.149	−0.123	−1.033 to −0.327	0.003*	1.16
	Moderately food insecure	−1.268	0.24	−0.131	−1.836 to −0.700	0.001*	1.11
	Severely food insecure	−1.554	0.628	−0.169	−3.040 to −0.069	0.043*	1.17
Age category	Older adolescent (15-16 years)	−0.556	0.072	−0.172	−0.726 to −0.385	<0.001*	1.01
Sex	Female	0.247	0.079	0.079	0.061 to 0.434	0.017*	1.01
Division	Rangpur	0.105	0.04	0.034	0.012 to 0.199	0.033*	1.02
Type of family	Joint	−0.058	0.095	−0.018	−0.282 to 0.166	0.561	1.01
Father's education	Illiterate	0.124	0.127	0.018	−0.176 to 0.423	0.362	1.21
	Primary	0.076	0.056	0.013	−0.056 to 0.209	0.216	1.28
	Secondary	0.239	0.078	0.075	0.054 to 0.424	0.018*	1.71
	Higher secondary	0.166	0.143	0.043	−0.172 to 0.504	0.283	1.5
Mother's education	Illiterate	−0.046	0.246	−0.011	−0.627 to 0.536	0.858	2.74
	Primary	−0.048	0.19	−0.014	−0.497 to 0.401	0.807	3.56
	Secondary	−0.048	0.209	−0.014	−0.542 to 0.445	0.823	3.67
	Higher secondary	−0.103	0.224	−0.025	−0.633 to 0.428	0.661	2.78
Monthly family income	Lower (<15,000 BDT)	−0.724	0.098	−0.169	−0.956 to −0.491	<0.001*	1.77
	Middle (15,000-30,000 BDT)	−0.255	0.061	−0.081	−0.400 to −0.111	0.004*	1.44
Type of house	Katcha	0.019	0.122	0.005	−0.270 to 0.307	0.883	1.33
	Semi-pucca	0.01	0.104	0.003	−0.235 to 0.256	0.924	1.33

TABLE 3: Multiple linear regression: association of household food insecurity with continuous BAZ

Cluster-robust (CR2, Bell-McCaffrey) linear regression with school clustering.

Reference categories: food secure, young adolescent, male, Rajshahi, nuclear family, graduate and above (father's and mother's education), upper income (>30,000 BDT), and pucca house.

R^2=0.146; adjusted R^2=0.135

*p<0.05

B: unstandardized regression coefficient; β: standardized coefficient; SE: standard error; CR2: cluster-robust variance estimator; CI: confidence interval; VIF: variance inflation factor; BAZ: BMI-for-age Z-score; BDT: Bangladeshi taka

Depressive and anxiety symptoms

The severity of depressive and anxiety symptoms is presented in Figure *3*. Depressive symptoms were measured using the PHQ-9 and anxiety symptoms using the GAD-7. Most participants had minimal depressive symptoms (904; 61.4%), while 386 (26.2%) had mild, 167 (11.3%) moderate, and 15 (1%)

moderately severe symptoms. No participant had severe depressive symptoms. Overall, 182 participants (12.4%; design-adjusted 95% CI 10.5-14.5) had moderate or higher (screen-positive) depressive symptoms (PHQ-9 ⩾10). The mean PHQ-9 score was 4.25±3.93, with a median of 3 (IQR 1-7).

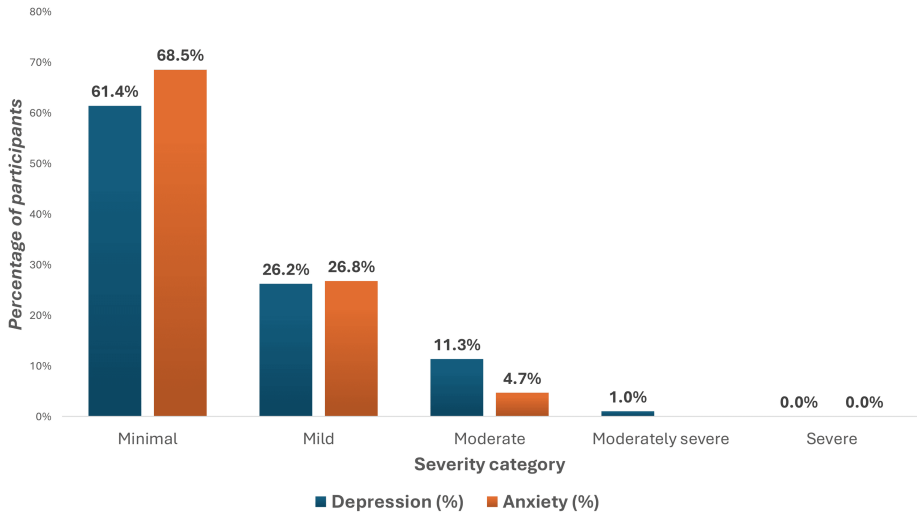

FIGURE 3: Severity of depressive (PHQ-9) and anxiety (GAD-7) symptoms among participants (N=1,472)

Blue bars represent depression, and orange bars represent anxiety. Severity was classified into five categories: minimal, mild, moderate, moderately severe, and severe. Percentages indicate the proportion of participants in each severity category.

PHQ-9: Patient Health Questionnaire-9; GAD-7: Generalized Anxiety Disorder-7

Minimal anxiety symptoms were found in 1,009 participants (68.5%), mild symptoms in 394 (26.8%), and moderate symptoms in 69 (4.7%). No participant had severe anxiety symptoms. Overall, 69 participants (4.7%; design-adjusted 95% CI 3.5-6.3) had moderate or higher (screen-positive) anxiety symptoms (GAD-7 ⩾10). The mean GAD-7 score was 3.39±3.19, with a median of 3 (IQR 1-6). According to the PHQ-9 and GAD-7 items, sleep disturbance (789; 53.6%) and worrying too much about different things (553; 37.6%) were the most frequently reported symptoms; details are presented in Appendix B and Appendix C.

The factors associated with depressive and anxiety symptoms are presented in Table *4*. Moderate and severe household food insecurity were significantly associated with depressive symptoms in both univariable and multivariable analyses. Participants from moderately food-insecure households had 4.73 times higher odds (95% CI 2.70-8.27), and those from severely food-insecure households had 3.73 times higher odds (95% CI 1.92-7.24), of depressive symptoms than participants from food-secure households. Female adolescents were not significantly associated with depressive symptoms after accounting for school clustering (AOR 0.67; 95% CI 0.35-1.26). Moderate (AOR 4.78; 95% CI 1.77-12.92) and severe food insecurity (AOR 7.03; 95% CI 2.55-19.35) were also associated with higher odds of anxiety symptoms. However, only 69 adolescents screened positive for anxiety symptoms, and the overall multivariable anxiety model was not statistically significant (χ^2=27.60; df=19; p=0.091). Mild food insecurity was not significantly associated with either outcome. Apart from father's secondary education for anxiety symptoms (AOR 0.60; 95% CI 0.41-0.87), no other sociodemographic characteristic showed a significant association. The multivariable model for depressive symptoms was statistically significant (χ^2=43.80; df=19; p=0.001; Nagelkerke R^2=0.056). Firth's penalized regression produced similar estimates for moderate (AOR 4.92; 95% CI 1.58-13.28) and severe food insecurity (AOR 7.06; 95% CI 2.32-19.55) in relation to anxiety symptoms.

Variables	Category	Depressive symptoms (PHQ-9 ≥10)						Anxiety symptoms (GAD-7 ≥10)					
		COR	95% CI	P-value	AOR	95% CI	P-value	COR	95% CI	P-value	AOR	95% CI	P-value
Household food insecurity	Mildly food insecure	1.52	0.84-2.75	0.138	1.61	0.82-3.16	0.142	1.34	0.52-3.44	0.483	1.75	0.69-4.46	0.198
	Moderately food insecure	3.95	2.50-6.24	<0.001*	4.73	2.70-8.27	<0.001*	3.38	1.38-8.29	0.015*	4.78	1.77-12.92	0.007*

	Severely food insecure	3.09	1.76-5.41	0.002*	3.73	1.92-7.24	0.002*	3.75	1.44-9.77	0.014*	7.03	2.55-19.35	0.003*
Age category	Older adolescent (15-16 years)	1.27	0.76-2.12	0.300	1.29	0.76-2.19	0.291	1.21	0.73-1.99	0.407	1.2	0.70-2.05	0.461
Sex	Female	0.66	0.36-1.20	0.142	0.67	0.35-1.26	0.176	0.91	0.50-1.65	0.713	0.93	0.48-1.80	0.793
Division	Rangpur	0.84	0.60-1.17	0.250	0.85	0.57-1.27	0.364	1.1	0.49-2.46	0.797	1.15	0.51-2.63	0.693
Type of family	Joint	0.9	0.52-1.55	0.648	0.9	0.53-1.52	0.644	1.18	0.78-1.80	0.373	1.18	0.76-1.83	0.398
Father's education	Illiterate	0.36	0.09-1.55	0.143	0.35	0.07-1.64	0.152	1.44	0.56-3.69	0.392	1.47	0.56-3.89	0.381
	Primary	1.05	0.48-2.29	0.884	0.93	0.37-2.34	0.859	0.39	0.06-2.61	0.283	0.36	0.06-2.03	0.204
	Secondary	1.04	0.75-1.44	0.774	0.93	0.62-1.41	0.704	0.63	0.40-1.01	0.053	0.6	0.41-0.87	0.014*
	Higher secondary	1.06	0.64-1.75	0.808	1	0.62-1.61	0.987	0.62	0.30-1.26	0.156	0.6	0.27-1.33	0.174
Mother's education	Illiterate	1.09	0.57-2.08	0.756	1.06	0.58-1.96	0.818	2.69	0.37-19.34	0.275	2.65	0.38-18.34	0.273
	Primary	1.07	0.59-1.95	0.801	1	0.49-2.05	0.992	2.34	0.54-10.16	0.212	2.41	0.48-12.17	0.238
	Secondary	1.08	0.40-2.96	0.855	1.01	0.34-3.06	0.978	2.92	0.68-12.49	0.125	2.98	0.58-15.32	0.160
	Higher secondary	0.94	0.49-1.82	0.834	0.89	0.45-1.78	0.704	3.43	0.71-16.60	0.107	3.31	0.69-15.83	0.114
Monthly family income	Lower (<15,000 BDT)	1.36	0.90-2.06	0.118	0.77	0.54-1.12	0.141	0.87	0.28-2.70	0.785	0.43	0.18-1.05	0.061
	Middle (15,000-30,000 BDT)	1.05	0.78-1.41	0.703	1.08	0.73-1.62	0.647	0.67	0.24-1.88	0.390	0.67	0.21-2.06	0.422
Type of house	Katcha	0.98	0.48-2.00	0.956	0.91	0.41-2.02	0.783	1.1	0.36-3.34	0.838	1.04	0.33-3.27	0.935
	Semi-pucca	1.4	0.90-2.19	0.114	1.34	0.88-2.06	0.146	1.06	0.44-2.52	0.888	1	0.47-2.15	1.000

TABLE 4: Univariable and multivariable logistic regression of factors associated with depressive and anxiety symptoms among school-going adolescents (N=1,472)

Logistic regression with generalized estimating equations (exchangeable correlation) and Mancl-DeRouen standard errors.

Reference categories: food secure, young adolescent, male, Rajshahi, nuclear family, graduate and above (father's and mother's education), upper income (>30,000 BDT), and pucca house.

Screen-positive symptoms were defined as PHQ-9 ≥10 or GAD-7 ≥10. The overall multivariable anxiety model was not significant (χ^2=27.60; df=19; p=0.091), and only 69 participants screened positive for anxiety.

*p<0.05

COR: crude odds ratio; AOR: adjusted odds ratio; CI: confidence interval; BDT: Bangladeshi taka; PHQ-9: Patient Health Questionnaire-9; GAD-7: Generalized Anxiety Disorder-7

Discussion

Food access at the household level can affect both adolescent diets and emotional well-being, making it

relevant to physical growth and mental health. To our knowledge, this study is among the first to examine household food insecurity in relation to nutritional status, depressive symptoms, and anxiety concurrently among school-going adolescents in northern Bangladesh. The focus on adolescents from selected areas of the Rajshahi and Rangpur divisions is particularly relevant given the substantial burden of household food insecurity in these regions. Examining nutritional and psychological outcomes within the same population, this study provides region-specific evidence that extends the existing literature on adolescent health in Bangladesh. Most households were food secure; however, household food insecurity showed a graded association with lower BAZ and was associated with higher odds of depressive and anxiety symptoms.

Household food insecurity

Most participants were young adolescents (12-14 years), with a mean age of 14.05 years; most fathers had secondary education, most mothers were housewives, and most families belonged to the middle-income group (15,000-30,000 BDT). Overall, 14.5% of households experienced some degree of food insecurity, and 5.7% experienced moderate or severe food insecurity. International evidence indicates a higher burden, with 25-30% of students across 95 countries reporting hunger [23], about two in five school-going adolescents across 59 countries reporting food insecurity [24], and 21% of households in a poor neighborhood of Kathmandu being food insecure [25]. Studies from Bangladesh have reported much higher levels, including food insecurity among 67.5% of adolescents in a rural area of central Bangladesh [26], severe food insecurity among 49% of children and adolescents in Dhaka slums [5], moderate to severe hunger among 61.7% of slum adolescents [27], food insecurity in about 85% of tea garden households in Sylhet [28], and food security in only 14-22% of poor households in the flood-prone north-east [16]. These differences should be interpreted cautiously. The present sample comprised school-enrolled students from households that may be more economically stable than those of slum-dwelling, marginalized, or out-of-school populations, and studies differed in their instruments, such as the HFIAS, hunger scales, single-item questions, or food consumption scores, and in their cut-offs. Households able to keep adolescents in secondary school are likely to have more regular income, and most families in this study belonged to the middle-income group, whereas the comparison studies largely focused on slum, tea garden, flood-prone, or very poor households. The score-based HFIAS categorization used in this study also differs from the frequency-based algorithm used in some studies, and household food insecurity may have been under-reported because of social desirability or stigma. Food insecurity was similar among male and female adolescents, consistent with multi-country evidence [23]. Nevertheless, the presence of severe food insecurity within ordinary classrooms indicates that affected students may remain unrecognized; schools in the Rajshahi and Rangpur divisions could include brief HFIAS-based screening in routine school health activities and link food-insecure students with school feeding and social safety-net programs.

Household food insecurity and nutritional status

Thinness was more common than overweight or obesity, and BAZ declined progressively with increasing severity of food insecurity after adjustment. This graded pattern is consistent with a meta-analysis [6] and with the high burden of thinness among tea garden children [28] and slum children and adolescents [5] in Bangladesh. Studies in Kathmandu [25] and rural central Bangladesh [26], however, did not find a clear association between household food security and adolescent nutritional status, possibly because of differences in sample size, measurement, and adjustment. Food-insecure households may reduce meal size, frequency, and dietary diversity, limiting the energy and nutrients needed for growth. Food security, however, does not guarantee a healthy diet: food-secure households may have enough food but still lack diverse, nutrient-rich foods, possibly explaining thinness among food-secure students and the higher frequency of overweight and obesity in this group [5]. Older age and lower and middle family income were also associated with lower BAZ, whereas female adolescents and adolescents with fathers educated to the secondary level had higher BAZ. The income finding agrees with Bangladeshi studies linking low income with poor food security and nutrition [5,26], whereas age and sex were not associated with nutritional status in rural central Bangladesh [26]. Thinness among male adolescents may reflect higher energy needs during the adolescent growth spurt. Students with low BAZ, particularly older male adolescents and those from food-insecure and low-income households, should be assessed for household food insecurity, dietary diversity, illness, possible intestinal parasitic infection, and other relevant health conditions, with treatment based on individual assessment rather than assuming that all male adolescents with lower BMI require supplements or medication.

Household food insecurity and depressive and anxiety symptoms

The association with depressive and anxiety symptoms was observed at moderate and severe levels of food insecurity, but not at the mild level. A multi-country analysis of school-going adolescents also found higher rates of anxiety and other psychosocial problems among food-insecure adolescents [24]. Similarly, research among adolescents in rural Pakistan identified associations between greater household food insecurity and increased depressive and anxiety symptoms in both male and female adolescents [29]. Studies in Bangladesh have linked food insecurity with depression in a nationwide adolescent survey [11], hunger with anxiety and depression among adolescents in Dhaka slums [27], and food insecurity with anxiety and depression among adults in underserved settlements of Khulna [30]. The lower burden in this study than in these underserved settings may reflect differences in poverty, age group, and instruments. After accounting for school clustering, no sociodemographic characteristic was associated with depressive symptoms, unlike findings

from a national survey and other studies reporting associations with female sex, older age, higher maternal education [11], and low income [18], potentially reflecting the narrow age range and predominantly middle-income sample in the present study. Paternal secondary education was inconsistently associated with lower anxiety. Persistent worry about food, shame among peers, family stress, maternal distress, and irregular meals may explain this association [29]. Because the overall multivariable anxiety model did not reach global statistical significance (p=0.091), the outcome event count was small (n=69), and the 95% CIs were wide, the observed associations between moderate or severe food insecurity and anxiety symptoms should be interpreted cautiously as exploratory rather than definitive. Students from moderately and severely food-insecure households should be screened with the PHQ-9 and GAD-7 through school health services, and school counsellors should provide counselling to both students and their parents. Schools could also foster a friendly and supportive environment, provide stipends or grants for students from poor households, and offer life-skills and income-generating training that motivates students from severely food-insecure households to stand on their own feet.

Strengths and limitations

The study used a stratified multistage cluster sample of school-going adolescents, validated Bangla instruments, duplicate calibrated anthropometric measurements with exact age in months, and cluster-adjusted analyses accounting for school clustering and sparse anxiety events. However, several limitations should be noted. First, the cross-sectional design precludes causal inference or determination of temporal direction between food insecurity, nutritional status, and psychological symptoms. Second, sampling was restricted to eight secondary schools and students enrolled in classes 9 and 10 (aged 12-16 years) using unweighted equal cluster allocation; therefore, the findings may not represent out-of-school adolescents, younger children, or adolescents in other geographical settings. Third, although small-sample corrections (CR2 and Mancl-DeRouen) were applied, inference across only eight school clusters limits degrees of freedom and reduces precision. Fourth, household food insecurity and socioeconomic data relied on self-reports and parent reports, which may be subject to recall and social desirability bias, and score-based HFIAS cut-offs differ from the standard FANTA HFIAP domain algorithm. Fifth, PHQ-9 and GAD-7 are screening tools rather than clinical diagnostic interviews, and the small number of anxiety cases (n=69) alongside the non-significant omnibus anxiety model (p=0.091) limited statistical precision. Finally, dietary intake, micronutrient status, and maternal mental health were not assessed.

Conclusions

In this cross-sectional study of school-going adolescents in northern Bangladesh, household food insecurity showed a graded inverse association with BAZ, with thinness more prevalent than overweight or obesity and most concentrated among adolescents from severely food-insecure households, male adolescents, older adolescents, and students from lower-income families. Moderate and severe household food insecurity were also associated with a significantly higher likelihood of depressive symptoms and an exploratory higher likelihood of anxiety symptoms, whereas mild food insecurity was not significantly associated with either psychological outcome. Based directly on these findings, school health programs in northern Bangladesh should integrate brief food insecurity screening, individual nutritional assessment for thin older male and low-income students, and targeted mental health screening with counselling and social safety-net linkages for students from moderately and severely food-insecure households.

Appendices

Appendix A

Appendix A presents the item-level responses to the Household Food Insecurity Access Scale (HFIAS) among the 1,472 students.

Item	Never n (%)	Rarely n (%)	Sometimes n (%)	Often n (%)
1. Worry that the household would not have enough food	1,072 (72.8%)	272 (18.5%)	64 (4.3%)	64 (4.3%)
2. Not able to eat the kinds of foods preferred	1,338 (90.9%)	42 (2.9%)	59 (4%)	33 (2.2%)
3. Ate a limited variety of foods	1,303 (88.5%)	70 (4.8%)	86 (5.8%)	13 (0.9%)
4. Ate some foods that you really did not want to eat	1,350 (91.7%)	67 (4.6%)	47 (3.2%)	8 (0.5%)
5. Ate a smaller meal than needed	1,374 (93.3%)	48 (3.3%)	26 (1.8%)	24 (1.6%)
6. Ate fewer meals in a day	1,363 (92.6%)	49 (3.3%)	31 (2.1%)	29 (2%)
7. No food of any kind in the household	1,424 (96.7%)	7 (0.5%)	17 (1.2%)	24 (1.6%)
8. Went to sleep at night hungry	1,434 (97.4%)	13 (0.9%)	25 (1.7%)	0 (0%)
9. Went a whole day and night without eating	1,441 (97.9%)	8 (0.5%)	23 (1.6%)	0 (0%)

TABLE 5: Household Food Insecurity Access Scale (HFIAS) item responses (N=1,472)

Appendix B

Appendix B presents the item-level responses to the Patient Health Questionnaire-9 (PHQ-9).

Item	Not at all n (%)	Several days n (%)	More than half the days n (%)	Nearly every day n (%)
1. Little interest or pleasure in doing things	903 (61.3%)	300 (20.4%)	232 (15.8%)	37 (2.5%)
2. Feeling down, depressed, or hopeless	883 (60%)	348 (23.6%)	225 (15.3%)	16 (1.1%)
3. Trouble falling or staying asleep or sleeping too much	683 (46.4%)	441 (30%)	224 (15.2%)	124 (8.4%)
4. Feeling tired or having little energy	945 (64.2%)	285 (19.4%)	130 (8.8%)	112 (7.6%)
5. Poor appetite or overeating	943 (64.1%)	234 (15.9%)	163 (11.1%)	132 (9%)
6. Feeling bad about yourself or that you are a failure	1,161 (78.9%)	162 (11%)	86 (5.8%)	63 (4.3%)
7. Trouble concentrating on things	1,231 (83.6%)	127 (8.6%)	67 (4.6%)	47 (3.2%)
8. Moving or speaking slowly or being fidgety or restless	1,269 (86.2%)	113 (7.7%)	55 (3.7%)	35 (2.4%)
9. Thoughts that you would be better off dead or of hurting yourself	1,336 (90.8%)	89 (6%)	41 (2.8%)	6 (0.4%)

TABLE 6: Patient Health Questionnaire-9 (PHQ-9) item responses (N=1,472)

Appendix C

Appendix C presents the item-level responses to the Generalized Anxiety Disorder-7 (GAD-7) among the same participants.

Item	Not at all n (%)	Several days n (%)	More than half the days n (%)	Nearly every day n (%)
1. Feeling nervous, anxious, or on edge	969 (65.8%)	271 (18.4%)	201 (13.7%)	31 (2.1%)
2. Not being able to stop or control worrying	923 (62.7%)	245 (16.6%)	249 (16.9%)	55 (3.7%)
3. Worrying too much about different things	919 (62.4%)	319 (21.7%)	146 (9.9%)	88 (6%)
4. Trouble relaxing	1,056 (71.7%)	202 (13.7%)	133 (9%)	81 (5.5%)
5. Being so restless that it is hard to sit still	1,165 (79.1%)	164 (11.1%)	88 (6%)	55 (3.7%)
6. Becoming easily annoyed or irritable	981 (66.6%)	317 (21.5%)	118 (8%)	56 (3.8%)
7. Feeling afraid as if something awful might happen	1,096 (74.5%)	277 (18.8%)	69 (4.7%)	30 (2%)

TABLE 7: Generalized Anxiety Disorder-7 (GAD-7) item responses (N=1,472)

Additional Information

Author Contributions

All authors have reviewed the final version to be published and agreed to be accountable for all aspects of the work.

Acquisition, analysis, or interpretation of data: Tarikul Gazi, Afsana Nazneen, Lamiya Tasnim Niloy, Md Sunyet A. Chowdhury, Nahin N. Nasa, Md Ibrahim R. Rume

Drafting of the manuscript: Tarikul Gazi, Afsana Nazneen, Lamiya Tasnim Niloy, Md Sunyet A. Chowdhury, Nahin N. Nasa, Md Ibrahim R. Rume

Concept and design: Irin Hossain, Shahria Sattar, Md Ziaul Islam

Critical review of the manuscript for important intellectual content: Irin Hossain, Shahria Sattar, Lamiya Tasnim Niloy, Md Ziaul Islam

Supervision: Irin Hossain, Shahria Sattar, Md Ziaul Islam

Disclosures

Human subjects: Informed consent for treatment and open access publication was obtained or waived by all participants in this study. Institutional Review Board of the National Institute of Preventive and Social Medicine (NIPSOM) issued approval NIPSOM/IRB/2026/12. **Animal subjects:** All authors have confirmed that this study did not involve animal subjects or tissue. **AI use statement:** The authors have declared that no AI tools were used during the work or in the drafting of this article. The authors take full responsibility for the work. **Conflicts of interest:** In compliance with the ICMJE uniform disclosure form, all authors declare the following: **Payment/services info:** All authors have declared that no financial support was received from any organization for the submitted work. **Financial relationships:** All authors have declared that they have no financial relationships at present or within the previous three years with any organizations that might have an interest in the submitted work. **Other relationships:** All authors have declared that there are no other relationships or activities that could appear to have influenced the submitted work.

Acknowledgements

The authors gratefully acknowledge the Institute of Public Health Nutrition (IPHN), the National Institute of Preventive and Social Medicine (NIPSOM), and the Department of Occupational and Environmental Health (OEH), NIPSOM, for their support and cooperation. The authors also extend their appreciation to the directors of IPHN and NIPSOM, evaluation committee members, district education officials, school authorities, and all participating students and their parents or guardians for their valuable cooperation.

References

1. The State of Food Security and Nutrition in the World 2026 . (2026). Accessed: 2026: https://openknowledge.fao.org/server/api/core/bitstreams/fbd7e989-deb5-415b-a5b9-bfa08269b9d7/content.
2. Food Security Statistics 2023. (2023). Accessed: November 4, 2026: https://objectstorage.ap-dcc-gazipur-1.oraclecloud15.com/n/axvjbnqprylg/b/V2Ministry/o/office-bbs/2024/12/334d2193735....
3. Shuvo SD, Hasan MM, Das TK, Hossain ME, Aktar T, Riazuddin M, Hasan MS: Food insecurity and its contributing determinants among rural households in the south-western region of Bangladesh, 2021: a cross-sectional study. Public Health Pract (Oxf). 2024, 8:100514. 10.1016/j.puhip.2024.100514
4. Islam MN, Madilo FK, Eesha S, et al.: Demographic determinants of food insecurity among rural adolescents (12-19 years) in Bangladesh: a cross-sectional study. Discov Public Health. 2025, 22:495. 10.1186/s12982-025-00892-0
5. Adiba A, Hossain S, Devnath N, et al.: Assessing food security and nutritional inequalities among children and adolescents in the urban slums of Bangladesh. J Biosci Public Health. 2025, 1:13-28. 10.5455/jbph.2025.02
6. Moradi S, Mirzababaei A, Mohammadi H, Moosavian SP, Arab A, Jannat B, Mirzaei K: Food insecurity and the risk of undernutrition complications among children and adolescents: a systematic review and meta-analysis. Nutrition. 2019, 62:52-60. 10.1016/j.nut.2018.11.029
7. Choedon T, Brennan E, Joe W, et al.: Nutritional status of school-age children (5-19 years) in South Asia: a scoping review. Matern Child Nutr. 2024, 20:e13607. 10.1111/mcn.13607
8. Pourmotabbed A, Moradi S, Babaei A, et al.: Food insecurity and mental health: a systematic review and meta-analysis. Public Health Nutr. 2020, 23:1778-90. 10.1017/S136898001900435X
9. Cisneros-Vásquez E, Smith L, Yañéz-Sepúlveda R, et al.: Beyond hunger: uncovering the link between food insecurity and depression, anxiety, and stress in adolescents. Curr Dev Nutr. 2025, 9:107453. 10.1016/j.cdnut.2025.107453
10. Cain KS, Meyer SC, Cummer E, et al.: Association of food insecurity with mental health outcomes in parents and children. Acad Pediatr. 2022, 22:1105-14. 10.1016/j.acap.2022.04.010
11. Mridha MK, Hossain MM, Khan MS, et al.: Prevalence and associated factors of depression among adolescent boys and girls in Bangladesh: findings from a nationwide survey. BMJ Open. 2021, 11:e038954. 10.1136/bmjopen-2020-038954
12. Islam MS, Rahman ME, Moonajilin MS, van Os J: Prevalence of depression, anxiety and associated factors among school going adolescents in Bangladesh: findings from a cross-sectional study. PLoS One. 2021, 16:e0247898. 10.1371/journal.pone.0247898
13. The state of food security and nutrition in the world 2021 . (2021). Accessed: 2026: https://www.who.int/publications/m/item/the-state-of-food-security-and-nutrition-in-the-world-2021 .
14. Mondal S, Wangdi K, Gray DJ, Kelly M, Sarma H: Prevalence and determinants of household food insecurity in the coastal regions, Bangladesh. Food Energy Secur. 2025, 14:e70092. 10.1002/fes3.70092
15. Coates J, Swindale a, Bilinsky P: Household Food Insecurity Access Scale (HFIAS) for Measurement of Food Access: Indicator Guide. Food and Nutrition Technical Assistance Project, Academy for Educational Development, Washington, DC; 2007.
16. Haque MA, Choudhury N, Ahmed SM, et al.: Food security status of Suchana-participating households in north-eastern rural Bangladesh. Front Public Health. 2022, 10:950676. 10.3389/fpubh.2022.950676
17. Tariqujjaman M, Rahman M, Wangdi K, Karmakar G, Ahmed T, Sarma H: Geographical variations of food insecurity and its associated factors in Bangladesh: evidence from pooled data of seven cross-sectional surveys. PLoS One. 2023, 18:e0280157. 10.1371/journal.pone.0280157
18. BMI-for-age (5-19 years). (2007). Accessed: November 4, 2026: https://www.who.int/tools/growth-reference-data-for-5to19-years/indicators/bmi-for-age.
19. Kroenke K, Spitzer RL, Williams JB: The PHQ-9: validity of a brief depression severity measure . J Gen Intern Med. 2001, 16:606-13. 10.1046/j.1525-1497.2001.016009606.x
20. Spitzer RL, Kroenke K, Williams JB, Löwe B: A brief measure for assessing generalized anxiety disorder: the GAD-7. Arch Intern Med. 2006, 166:1092-7. 10.1001/archinte.166.10.1092
21. The adolescent health indicators recommended by the Global Action for Measurement of Adolescent Health . (2024). Accessed: November 4, 2026: https://www.who.int/publications/i/item/9789240092198.
22. Moonajilin MS, Rahman ME, Islam MS: Relationship between overweight/obesity and mental health disorders among Bangladeshi adolescents: a cross-sectional survey. Obes Med. 2020, 18:100216. 10.1016/j.obmed.2020.100216
23. Fram MS, Nguyen HT, Frongillo EA: Food insecurity among adolescent students from 95 countries is associated with diet, behavior, and health, and associations differ by student age and sex. Curr Dev Nutr. 2022, 6:nzac024. 10.1093/cdn/nzac024
24. Rahman MA, Siu JY: Food insecurity and adolescents psychosocial health problems globally: observations based on school going adolescents from 59 countries. Psychiatry Res. 2025, 352:116687. 10.1016/j.psychres.2025.116687
25. K C D, Ulak N, Poudyal A, Shrestha N, Gautam N, Ghimire L, Paudel U: Household food security access and nutritional status among early adolescents in a poor neighborhood of Sinamangal, Nepal. Curr Dev Nutr. 2021, 5:nzab127. 10.1093/cdn/nzab127
26. Akter N, Mohammad Kurshed AA: Factors associated with adolescent food security and nutritional status in a selected rural area of the central region of Bangladesh. Biores Com. 2024, 10:1573-82. 10.3329/brc.v10i2.74583
27. Yasmin ST, Yasmin ST, Hong SA, Sultan S: Associations between hunger and mental health among adolescents in Bangladeshi slums amid COVID-19. Thai J Public Health. 2024, 54:796-812. 10.14456/thjph.2024.6
28. Iqbal MS, Palmer AC, Waid J, Rahman SM, Bulbul MM, Ahmed T: Nutritional status among school-age children of Bangladeshi tea garden workers. Food Nutr Bull. 2020, 41:424-9. 10.1177/0379572120965299
29. Campisi S, Perquier F, Wasan Y, et al.: Impact of household food insecurity and nutrition on depression and anxiety symptoms among adolescents living in rural Pakistan. Glob Ment Health (Camb). 2025, 12:e79.

10.1017/gmh.2025.10006

30. Shuvo SD, Mandal AC, Khanum L, Bashar MA, Roy D, Paul DK: Food insecurity and dietary intakes as correlates of anxiety and depression in underserved settlements in Khulna Division of Bangladesh: a developing country perspective. BMJ Open. 2025, 15:e096371. 10.1136/bmjopen-2024-096371