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Demographic determinants of food insecurity among rural adolescents (12–19 years) in Bangladesh: a cross-sectional study

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Abstract

Background Food insecurity (FI) is a critical public health issue, particularly among adolescents in rural settings, where economic disparities and limited access to nutritious food heighten vulnerability. This study aimed to evaluate the food security status and identify its demographic determinants among rural adolescents in Bangladesh.

Methods A cross-sectional study was conducted between January and March 2023 using a simple random sampling strategy. Data were collected through an interviewer-administered structured questionnaire in the Kurigram and Patuakhali districts of Bangladesh. A total of 529 adolescents aged 12 to 19 years were recruited, including 274 males and 255 females. Multivariate logistic regression was applied, with model diagnostics (e.g., Hosmer-Lemeshow test, VIF for multicollinearity) ensuring robustness.

Results The overall prevalence of food security was 37.6%, while 62.4%of adolescents experienced some level of FI. Male adolescents were less likely to be food secure (AOR = 0.46, 95% CI = 0.29–0.74). Adolescents whose fathers had no formal education (AOR = 0.14, 95% CI = 0.03–0.74), primary education (AOR = 0.21, 95% CI = 0.05–0.86), or secondary education (AOR = 0.19, 95% CI = 0.05–0.72) were less likely to be food secure. Additionally, adolescents from households with a monthly income of < 15000 BDT (approximately $125 USD) (AOR = 0.07, 95% CI = (0.02–0.25) or 15,000–30,000 BDT (approximately $125–250 USD) (AOR = 0.22, 95% CI = (0.07–0.72) were less likely to be food secure. Concersely, adolescents who perceived their household income as sufficient (AOR = 5.29, 95% CI = (3.10–9.03) were more likely to be food secure.

Conclusion The findings highlight the need for targeted interentions to improve food security among rural adolescents, particularly among males those from families with lower incomes and education levels. Policy measures should focus on strengthening nutritional assistance progrms, economic supports, and school-based food initiatives to promote food security and overall adolescent well-being.

Keywords Food insecurity, Rural adolescents, Demographic determinants, Bangladesh

1 Introduction

Food insecurity (FI), an urgent public health concern, is defined by the US Department of Agriculture (USDA) as limited or uncertain access to nutritionally sufficient and safe foods at all times due to a lack of enough money and necessary resources hampers normal growth and healthy life [1]. Adolescence (10–19 years), a nutritionally vulnerable time, creates an increased need for many nutrients due to rapid physical growth [2]. Several studies have reported that FI negatively impacts adolescents' health. These effects are attributed to their increased nutritional demands, rapid physical growth, and psychological vulnerability. FI in adolescents has been linked to poor overall health, poor academic performance, overweight or obesity, and mental health issues such as depression and anxiety. Additionally, FI contributes to substance usage, suicidal ideation, mental disorders, increased violence perpetration, cardiovascular diseases, iron deficiency anemia, and decreased access to healthcare [3–11]. These effects are especially concerning during adolescence, a critical developmental period that shapes long-term health and well-being.

Despite the progress, the Global Food Security Index (GFSI) 2021 has classified Bangladesh as a high-risk country for FI [12]. In Bangladesh, around 25% of the population is food insecure, owing to the country's low performance in assuring quality and safe food, using natural resources, and adopting climate-smart agriculture by 2020 [13]. Furthermore, a significant flood of Rohingya refugees from Myanmar, which requires quick and comprehensive relief assistance, threatens FI in Bangladesh [14]. In addition, the continuing COVID-19 pandemic exacerbates FI. One-quarter of households experiencing moderate to severe FI during the COVID-19 pandemic [15]. FI among adolescents in Bangladesh is increasing, particularly during economic recessions like the COVID-19 pandemic. Yasmin et al. (2023) reported an increase in FI among adolescents attributed to income loss in low-income households, intensifying pre-existing vulnerabilities in urban slum areas [16]. The study emphasizes that insufficient efforts to tackle this issue have exacerbated the situation, highlighting the need for effective screening for FI. Similarly, Akter et al. (2021) reported that adolescents from food insecure homes faced a markedly elevated risk of inadequate dietary diversity, with FI directly associated with poor nutritional outcomes in this population [17]. Previous FI research in Bangladesh and other South Asian countries focused on women and children under the age of five [18, 19]. Despite significant advances in FI studies, adolescents remain understudied compared to younger children and adults.

The food security situation in Bangladesh is a complex issue, exacerbated by policy gaps that hinder effective response and resilience to FI problems. Despite improvements in food production and agricultural productivity, weakness in policy fameworks continue to undermine efforts to achieve suatainable food security. A significant issues lies disconnect between agricultural productivity enhancements and socio-economic accessibility to food resources. This creates disparities in food security across various demographics, particularly among the poor and vulnerable populations [20]. This is echoed by the findings of Murshed-E-Jahan et al., (2010) emphasizing that, despite increased domestic food supply, the purchasing power of the ultra-poor remains inadequate, limiting their access to resources [21]. Additionally, the inadequacy of policies that address nutritional quality alongside food quantity is another issue. The emphasis on increasing food production, primarily rice, has overshadowed the need for dietary diversification

and quality, which are essential for tackling malnutrition in rural populations [22]. Despite improvements in food security, people in Bangladesh still lack dietary diversification, contributing to nutritional imbalance. Gender inequities often dictate food distribution within households. This reflects another gap in policies that fail to target the specific needs of marginalized groups, such as women, who play a critical role in agricultural production and food security [23].

Although adolescents make up 21% of the population in Bangladesh, little is known about their demographic predictors and FI estimations [24]. According to the teenage literature on FI, 16–17% of adolescents in the US and Canada are food insecure [25, 26], whereas 20.5–55.2% of adolescents in developing nations, including Ethiopia, Lebanon, Iran, and Venezuela were found to be food insecure [27–30]. A prior study in Iran of adolescents from Esfahanian households aged 14 to 17 found a prevalence of FI of 36.6% [31]. The frequency of FI among high school females in two districts was determined to be 37.1% and 71.3%, respectively, by another team of researchers from Brazil [32]. The main predictors of FI among teenagers were found to be gender, household FI, place of residence, dependence ratio, and low socioeconomic position, according to a longitudinal study carried out in Southern Ethiopia [27]. This was comparable to studies done in Brazil and Canada [26, 32]. Salvo et al. summarized that adolescents' grade level, poverty status, poorer household income, parent education level, poor parent health, unsafe school, and unsafe neighborhood were associated with both FI and mental health risks [33].

According to a USDA report from 2007, studies revealed that teenagers might be at a higher risk of FI because the prevalence of FI in adolescents was twice as high in households with children aged 4 or younger [4, 9]. Furthermore, an analysis of child-level food security data from 2010 to 2011 finds that families with teenagers are twice as likely to experience FI and three times as likely to have extremely low food security as households with only younger children [4]. This study also showed that adults protect younger children more than older children and adolescents against the effects of FI [4]. However, a comparison of FI at the individual adolescents with household level has been examined in different settings and explored that efforts from the household adults to protect adolescents from FI remain unsuccessful [27, 28].

Most studies on adolescent FI focus on urban, low-income, national, and international samples, neglecting rural communities [27, 34–37]. Thirty-six million adolescents currently live in Bangladesh, most of whom live in rural areas [24]. Adolescents from rural areas of Bangladesh experience pockets of inequality and vulnerability in health, including lower access to healthcare [38]. Rural adolescents tend to experience the persistence of FI and struggle more for adequate food [38]. FI experience and the possible consequences of those experience is essential, but studies are limited on adolescent FI, especially in rural Bangladesh, raising uncertainty about adolescent FI. Therefore, in this study, we first determined the prevalence of FI among adolescent students and, second, examined the association between adolescents' demographics and FI by using the USDA children (aged 12–19 years) food security scale in rural Bangladesh.

The study hypothesizes that adolescents in rural Bangladesh have much higher rates of FI than in high-income and some developing countries. Demographic factors such as gender, household income, and parental education are likely to have an impact on FI levels. Male adolescents are hypothesized to experience higher FI due to greater dietary

needs and social considerations, but lower household income and parental education levels are expected to increase FI.

2 Methodology

2.1 Study design and setting

To address the goal of our study, a cross-sectional survey was done among school-aged adolescents (aged 12–19 years) in two preselected districts including Kurigram and Patuakhali. Kurigram is located in northern Bangladesh, along the border with India, and has a population of 2.0 million people, with a male/female ratio of 95 [39, 40]. Patuakhali is a city in southern Bangladesh with a population of 1.5 million people and a sex ratio (male/female) of 96 [39, 40]. Kurigram and Patuakhali districts each have 257 and 288 high schools. These districts were selected due to their high poverty rates. The Kurigram district in Bangladesh has the highest rate of poverty in the country, at 70.8%, according to the Household Income and Expenditure Survey, the Bangladesh Bureau of Statistics (BBS), and the World Food Programme (WFP) [39, 40]. Furthermore, the Patuakhali district has a poverty rate of 37.2% [39, 40]. These districts were chosen due to their high poverty rates and climate variability (heavy rainfall, flooding, temperature variation, cyclones, and salinity), which made them vulnerable to FI [41–44]. The socioeconomic challenges, coupled with environmental factors, render Kurigram and Patuakhali ideal locations for investigating adolescent FI in this study.

2.2 Inclusion and exclusion criteria

This survey covered all adolescents (12–19 years old) attending chosen schools in the Kurigram and Patuakhali districts. Adolescents who were critically ill during data collection were barred from participating in the study. During data collection, a small number of adolescents ($n = 5$) were identified as critically ill and were therefore excluded from participation. Criticall illness in this context referred to conditions that severely impaired the ability to participate in the survey, such as hospitalizations, severe infections or debilitating chronic conditions.

2.3 Sample size determination and sampling technique

The single proportion formula ($n = z^2pq/d^2$) was used to calculate the sample size while taking into account the following hypotheses: a prevalence of FI of 50% ($p = 0.5$) (since there was no previous study on a similar population) [45], 4.5% margin of error, confidence level at 95%. The calculated sample size was 475. After adjusting for the 10% non-response rate, the final sample size was 522. Data were collected from four different conveniently selected rural high schools from each district. The schools were choosen to ensure a representative sample of rural adolescents from various socioeconomic backgrounds, considering factors such as school size, local infrastructure, and regional features. Although convenience sampling was used due to logistical constraints, the selected schools were considered to reflect the larger demographic features of the districts, ensuring a relevant and representative sample for the study. To choose representative samples, the researcher utilized student records provided by the different school administrations. Using the list, a sample frame was created for each school. The sample frame includes high school students who were selected and whose parents provided their consent to participate in the data collection, as well as students who met the additional

requirements specified by the researcher. The researcher asked the authorities to help in distributing copies of the parent's permission, informed consent, and student's assent forms. Both parental consent and student asent were required for participation, ensuring that children voluntarily agreed to take part in the study. Finally, participants were randomly selected from the sampling frame and interviewed outside of the classroom at the schools. The questionnaire lacked names and identification to protect participants' privacy. However, five hundred and twenty-nine (529) students were selected from eight schools for the current study.

2.4 Data collection procedures, tools, and quality control

Data were collected using a pretested, structured, and interviewer-administered questionnaire (between January and March, 2023). The questionnaire was initially prepared in English, then translated to Bengali and retranslated into English by language experts to maintain consistency. Eight students with Bachelor's degrees in nutrition and food science (six for data collection and two for supervisors) were recruited and trained for 3 days by the principal investigator about the objectives and whole data collection process to minimize the interindividual variability. A pretest was conducted on 5% of the total sample size (and not included in the final data) to evaluate the reliability and validity of the survey instruments. Based on the pretest results, the questionnaire was updated and edited to avoid ambiguity before the final data collection. The data were checked daily for completeness and accuracy. Data collectors were provided continuous supervision throughout the procedure. To maintain confidentiality, all personal data were anonymized. Furthermore, all collected information was exclusively used for research purposes, and participants were fully informed about the confidentiality measures during the consent process.

2.5 Variables and measurements

FI was considered as the dependent variable in our study, whereas socio-demographic and socio-economic (age, gender, education status, type of school, father's education level, mother's education level, mother's occupation) and household characteristics (number of living rooms, household head, household size, no of children in a family, monthly family income, total earning members, and household income perception) are considered as predictors. The self-administered food security survey module [46], developed by the US Department of Agriculture, for children ages 12 and older was used to determine food security status. USDA Food Security scale is valid in various non-US populations of adolescents [47–49]. The scale consists of nine questions about the household food situation during the month before the evaluation, with three response possibilities ("a lot," "occasionally," and "never"). "A lot" and "occasionally" was interpreted positively, whereas "never" was interpreted negatively. The raw score is the sum of affirmative responses across all scale items. They were classified as 1) food insecure if their raw score was equal to or greater than four, 2) food insecure if their raw score was two or three but included a negative response in the item related to worrying that food at home would run out (item 1), or 3) food insecure if their raw score was three and included an affirmative response to item 1 and a negative response in the item related to meals only consisting of a few types of cheap foods (item 3). They were considered as 1) food secure if the raw score was less than or equal to one, 2) if the raw score ranged

between two and three but included affirmative responses for items one and three, or 3) if the raw score was equal to two but included an affirmative response for item one but a negative response for item three. Additionally, the internal consistency of the scale was evaluated using Cronbach's alpha, which produced a value of 0.915, indicating an adequate level of internal consistency.

2.6 Statistical processing

For data analysis, the Statistical Package for Social Science (SPSS) version 28 was utilized. Microsoft Excel was used to enter the data. The final descriptive statistics (such as frequencies, percentages, averages, and means) were used to characterize the data's core properties. To assess the relationship between FI and the demographic factors, the Chi-square test was performed. The multicollinearity of the predictor variables was examined (cut off 5) [50]. The goodness of fit tests and appropriate model diagnostics were conducted. The fitness of the model was determined using the Hosmer and Lemeshow test *p*-value (0.774). All the variables from the bivariate analysis were included in the logistic regression model for multivariate analysis. The results of regression analyses were reported with 95% confidence intervals for both the crude/unadjusted odds ratios (COR) and the adjusted odds ratios (AOR) (CIs). The significance threshold was set at 0.05.

3 Results

3.1 Characteristics of the respondents

Table 1 shows the socio-demographic information of the participants in the study. Males made up 51.6% of the total (529) adolescent participants in this study. The average age was 14.8 ± 1.37, and more than half of the participants (51.6%) were between the ages of 14 and 15. The largest percentage (35.3%) of the respondents were in the 8th grade. The majority of responders (87.1%) attended government/ semi-government schools. More than one-third of the interviewees (34.6%) said their fathers completed secondary school, and (40.1%) said their mothers completed secondary school. The vast majority of their mothers (94%) were housewives. In terms of room numbers in their home, 65.8% had 3–4 rooms in their various houses. Men headed about 95.5% of the households, and 52.2% of their families had five or more members. The majority of the participants had one earning person (82.6%) in the family. Lastly, roughly half of the participants (49.5%) and 58%, respectively, reported having a monthly family income of less than 15,000 Bangladeshi taka (BDT) and believing they had an adequate household income (Fig. 1).

3.2 Prevalence of food security among rural adolescents

The prevalence of FI showed that 62.4% of survey participants were food insecure, while 37.6% were food secure.

3.3 Association of demographic variables with food security status

Table 2 shows the results of the relationship between demographic characteristics and food security. Food security is strongly related to age, gender, father's education level, mother's education level, mother's occupation, family head, number of living rooms, monthly family income, and perception of household income. Among teenagers over the age of 16, 73.0% had FI, compared to 64.5% for those aged 14 to 15 years and 39.2%

Table 1 Socio-demographic characteristics of the survey participants ($N = 529$)

Variables	Category	*n*	%
Age (years)	12–13	97	18.3
	14–15	273	51.6
	≥ 16	159	30.1
Gender	Male	274	51.8
	Female	255	48.2
Education status[a]	7th grade	6	1.1
	8th grade	187	35.3
	9th grade	185	35.0
	10th grade	151	28.5
Type of school	Government / Semi-government	461	87.1
	Private	68	12.9
Father's education level	No formal education	57	10.8
	Primary school completed	84	15.9
	Secondary school completed	183	34.6
	Higher secondary school completed	151	28.5
	Bachelor's degree or above	54	10.2
Mother's education level	No formal education	45	8.5
	Primary school completed	112	21.2
	Secondary school completed	212	40.1
	Higher secondary school completed	121	22.9
	Bachelor's Degree or above	39	7.4
Mothers' occupation	Job holder/ Worker	32	6.0
	Housewife	497	94.0
Number of living room	< 3	96	18.1
	3 to 4	348	65.8
	> 4	85	16.1
Household head	Male	505	95.5
	Female	24	4.5
Household size	< 5	201	38.0
	5 to 6	276	52.2
	> 6	52	9.8
No. of children in the family	< 3	61	11.5
	3	225	42.5
	> 3	243	45.9
Monthly family income (BDT)	< 15,000	262	49.5
	15,000 to 30,000	228	43.1
	> 30,000	39	7.4
Total earning members	One	437	82.6
	Two or more	92	17.4
Household income perception	Sufficient	307	58.0
	Insufficient	222	42.0

[a]The study population in this study consisted of adolescents in grades 7–10 (12–19 years old) because grades 6–10 are regarded as secondary education in Bangladeshi schools

for those aged 12 to 13 years; with a moderate effect size (Cramér's $V = 0.239$, $\chi^2 = 30.34$, $p < 0.001$). Males were more likely to be FI than females (69.7% vs. 30.3%, $\chi^2 = 13.00$, $p < 0.001$), but the effect size was small (Cramér's $V = 0.157$). Furthermore, adolescents with non-formally educated fathers had significantly higher FI (87.7%) compared to those whose father had a bachelor's degree or higher (18.5%), with a large effect size (Cramér's $V = 0.361$, $\chi^2 = 69.00$, $p < 0.001$). A similar trend was observed for maternal education where adolescents with non-formally educated mothers had a FI prevalence of 84.4%, while those with mothers holding a bachelor's degree or above had a FI

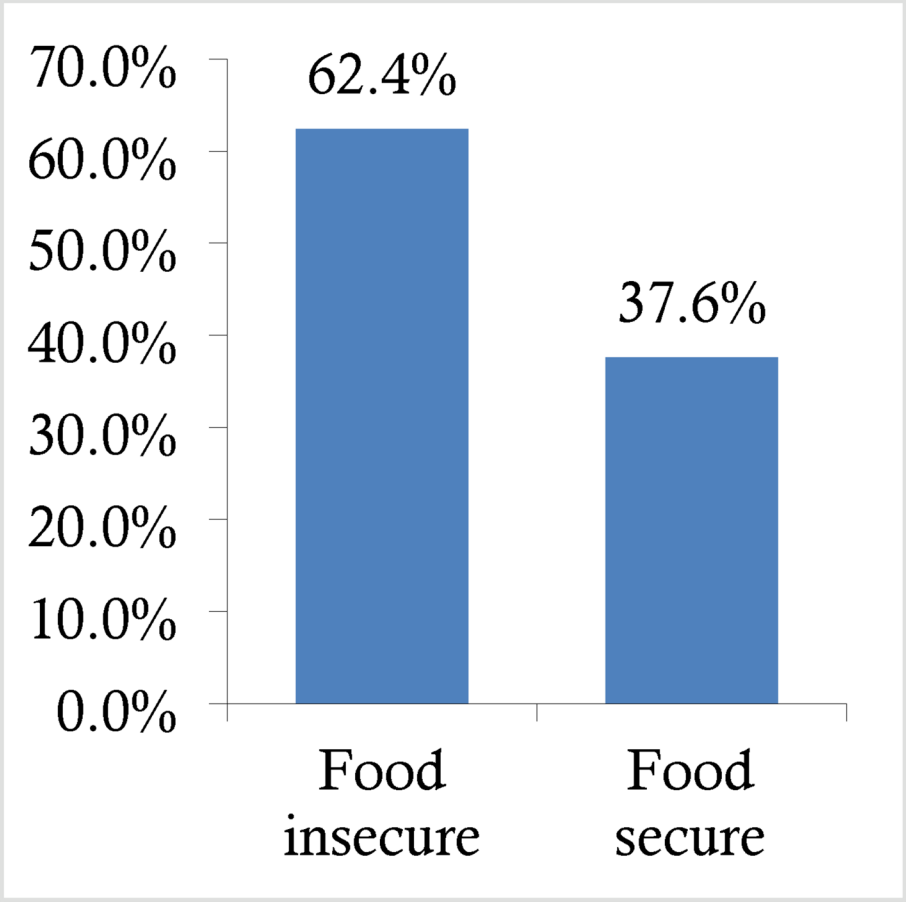

Fig. 1 Prevalence of food security and rural adolescents in Bangladesh

prevalence of only 20.5% (Cramér's V = 0.311, $\chi^2 = 51.18$, $p < 0.001$). The monthly family income was a significant determinant, with 82.1% of adolescents in households earning less than 15,000 BDT experiencing FI, compared to only 10.3% in households earning more than 30,000 BDT (Cramér's V = 0.449, $\chi^2 = 106.62$, $p < 0.001$). Similarly, the perception of household income was significantly related with FI; 86.9% of adolescents who perceived their household income as insufficient were food insecure, while 44.6% of those who perceived it as sufficient were food insecure (Cramér's V = 0.431, $\chi^2 = 98.29$, $p < 0.001$). Other variables, including the number of living rooms (Cramér's V = 0.197, $\chi^2 = 20.48$, $p < 0.001$) and female-headed households (Cramér's V = 0.094, $\chi^2 = 4.70$, $p = 0.030$), exhibited small-to-moderate effect sizes. However, the number of children, household size, education status, and type of school all exhibited weak or non-significant associations (Cramér's V < 0.10).

3.4 Predictors of food security

The FI predictors are shown in Table 3. In our investigation, the gender, father's education, monthly family income, and household perception of income all strongly predicted the outcome variable. Male participants were 56% (AOR = 0.46, 95% CI = 0.29–0.74) less likely than female participants to report having access to food. Adolescents were 86%, 79%, and 81% less likely to be food secure if their fathers had no formal education (AOR = 0.14, 95% CI = 0.03–0.74), primary education (AOR = 0.21, 95% CI = 0.05–0.86),

Table 2 Association of demographic variables with food security status ($N = 529$)

Variables	Category	Food insecure (62.4%)		Food secure (37.6%)		χ^2	*p*-value	Cramér's V
		n	%	n	%			
Age	12–13	38	39.2	59	60.8	30.34	**< 0.001**	**0.239**
	14–15	176	64.5	97	35.5			
	≥ 16	116	73.0	43	27.0			
Gender	Male	191	69.7	83	30.3	13.00	**< 0.001**	**0.157**
	Female	139	54.5	116	45.5			
Education status[a]	7th grade	5	83.3	1	16.7	5.77	0.123	0.104
	8th grade	105	56.1	82	43.9			
	9th grade	123	66.5	62	33.5			
	10th grade	97	64.2	54	35.8			
Type of school	Government / Semi-government	292	63.3	169	36.7	1.41	0.236	0.052
	Private	38	55.9	30	44.1			
Father's education level	No formal education	50	87.7	7	12.3	69.00	**< 0.001**	**0.361**
	Primary school completed	60	71.4	24	28.6			
	Secondary school completed	126	68.9	57	31.1			
	Higher secondary school completed	84	55.6	67	44.4			
	Bachelor's degree or above	10	18.5	44	81.5			
Mother's education level	No formal education	38	84.4	7	15.6	51.18	**< 0.001**	**0.311**
	Primary school completed	83	74.1	29	25.9			
	Secondary school completed	138	65.1	74	34.9			
	Higher secondary school completed	63	52.1	58	47.9			
	Bachelor's degree or above	8	20.5	31	79.5			
Mothers' occupation	Job holder/ Worker	14	43.8	18	56.3	5.04	**0.025**	**0.098**
	Housewife	316	63.6	181	36.4			
Number of living room	< 3	79	82.3	17	17.7	20.48	**< 0.001**	**0.197**
	3 to 4	205	58.9	143	41.1			
	> 4	46	54.1	39	45.9			
Household head	Male	310	61.4	195	38.6	4.70	**0.030**	**0.094**
	Female	20	83.3	4	16.7			
Household size	< 5	129	64.2	72	35.8	3.01	0.222	0.075
	5 to 6	164	59.4	112	40.6			
	> 6	37	71.2	15	28.8			
No. of children in the family	< 3	38	62.3	23	37.7	1.49	0.475	0.053
	3	134	59.6	91	40.4			
	> 3	158	65.0	85	35.0			
Monthly family income (BDT)	< 15,000	215	82.1	47	17.9	106.62	**< 0.001**	**0.449**
	15,000 to 30,000	111	48.7	117	51.3			
	> 30,000	4	10.3	35	89.7			
Total earning members	One	280	64.1	157	35.9	3.06	0.080	0.076
	Two or more	50	54.3	42	45.7			
Household income perception	Sufficient	137	44.6	170	55.4	98.29	**< 0.001**	**0.431**
	Insufficient	193	86.9	29	13.1			

[a]The study population in this study consisted of adolescents in grades 7–10 (12–19 years old), because grades 6–10 are regarded as secondary education in Bangladeshi schools. Bold = Indicates significance

Table 3 Socio-demographic predictors of adolescents' food security ($N = 529$)

Variables	Categories	*p*-value	COR (95% CI)	*p*-value	AOR (95% CI) (Nagelkerke's *R* Square = 0.469)	VIF
Age	12–13	**< 0.001**	**4.19 (2.45–7.17)**	0.108	2.11 (0.85–5.22)	1.801
	14–15	0.070	1.49 (0.97–2.28)	0.904	1.04 (0.55–1.96)	
	≥ 16		Reference	Reference		
Gender	Male	**< 0.001**	**0.52 (0.36–0.74)**	**0.001**	**0.46 (0.29–0.74)**	**1.044**
	Female		Reference	Reference		
Education status	7th grade	0.356	0.36 (0.04–3.15)	0.771	0.68 (0.05–8.91)	1.563
	8th grade	0.132	1.40 (0.9–2.18)	0.884	0.95 (0.46–1.94)	
	9th grade	0.666	0.91 (0.58–1.42)	0.582	0.84 (0.44–1.98)	
	10th grade		Reference	Reference		
Type of school	Government / Semi-government	0.237	0.73 (0.44–1.23)	0.487	1.28 (0.64–2.54)	1.091
	Private		Reference	Reference		
Father's education level	No formal education	**< 0.001**	**0.03 (0.01–0.09)**	**0.021**	0.14 (0.03–0.74)	1.700
	Primary school completed	**< 0.001**	**0.09 (0.04–0.21)**	**0.031**	0.21 (0.05–0.86)	
	Secondary school completed	**< 0.001**	**0.10 (0.05–0.22)**	**0.015**	0.19 (0.05–0.72)	
	Higher secondary school completed	**< 0.001**	**0.18 (0.08–0.39)**	**0.138**	0.36 (0.10–1.38)	
	Bachelor's degree or above		Reference	Reference		
Mother's education level	No formal education	**< 0.001**	**0.05 (0.02–0.15)**	0.696	0.69 (0.10–4.57)	1.745
	Primary school completed	**< 0.001**	**0.09 (0.04–0.22)**	0.692	0.72 (0.14–3.70)	
	Secondary school completed	**< 0.001**	**0.14 (0.06–0.32)**	0.788	0.81 (0.17–3.89)	
	Higher secondary school completed	**0.001**	**0.24 (0.10–0.56)**	0.473	0.56 (0.12–2.71)	
	Bachelor's degree or above		Reference	Reference		
Mothers' occupation	Job holder/ Worker	0.028	2.24 (1.09–4.62)	0.464	0.68 (0.24–1.93)	1.195
	Housewife		Reference	Reference		
Number of living room	< 3	**< 0.001**	**0.25 (0.13–0.50)**	0.051	0.41 (0.17-1.00)	1.197
	3 to 4	0.423	0.82 (0.51–1.33)	0.442	0.77 (0.40–1.49)	
	> 4		Reference	Reference		
Household head	Male	0.039	3.15 (1.06–9.34)	0.221	2.25 (0.62–8.25)	1.098
	Female		Reference	Reference		
Household size	< 5	0.346	1.38 (0.71–2.68)	0.146	2.14 (0.77–5.93)	1.512
	5 to 6	0.114	1.68 (0.88–3.21)	0.089	2.17 (0.89–5.29)	
	> 6		Reference	Reference		
No. of children in the family	< 3	0.691	1.13 (0.63–2.01)	0.946	0.97 (0.44–2.18)	1.346
	3	0.223	1.26 (0.87–1.84)	0.905	1.04 (0.57–1.88)	
	> 3		Reference			
Monthly family income (BDT)	< 15,000	**< 0.001**	**0.02 (0.01–0.07)**	**< 0.001**	**0.08 (0.02–0.25)**	**1.452**
	15,000 to 30,000	**< 0.001**	**0.12 (0.04–0.35)**	**0.012**	**0.22 (0.07–0.72)**	
	> 30,000		Reference	Reference		
Total earning members	One	0.081	0.67 (0.42–1.05)	0.933	0.97 (0.51–1.86)	1.204
	Two or more		Reference	Reference		
Household income perception	Sufficient	**< 0.001**	**8.26 (5.26–12.96)**	**< 0.001**	**5.29 (3.10–9.03)**	**1.263**
	Insufficient		Reference	Reference		

AOR = Adjusted odds ratio, COR = Crude odds ratio, Bold = Indicates significance, VIF = Variance inflation factor

or secondary education (AOR = 0.19, 95% CI = 0.05–0.72). Adolescents from low-income and middle-income families were 93% (AOR = 0.07, 95% CI = 0.02–0.25) and 78% (AOR = 0.22, 95% CI = 0.07–0.72) less likely to report food security, respectively than those from higher-income families. Lastly, participants with sufficient household

income were 5.29 times (AOR = 5.29, 95% CI = 3.08–8.83) more likely to experience food security than those with insufficient household income. To explore potential interaction effects, we constructed an additional regression model including interaction terms between gender and household income (see Supplementary Table 1). The interactions, male × <15,000 BDT (AOR = 1.39, 95% CI = 0.13–14.84) and male × 15,000–30,000 BDT (AOR = 1.10, 95% CI = 0.11–11.17) were included but not statistically significant. The interaction terms male × >30,000 BDT, female × <15,000 BDT, and female × 15,000–30,000 BDT were excluded from the final model to minimize redundancy, avoid multicollinearity, and preserve model stability.

4 Discussion

The purpose of the current cross-sectional study was to ascertain the prevalence and determinants of FI among Bangladeshi rural adolescents. According to our findings, the overall prevalence of FI among adolescents was 62.4% (Table 2). Several demographic and household factors were found to have a significant impact on the prevalence of FI among school adolescents.

The prevalence of FI in our sample, measured using the same scale, was substantially greater than that seen in children in regional and remote Western Australia (20.1%) [51], Portuguese adolescents (9.5%) [49], and Spanish adolescents (18.3%) [52]. The results of the present study revealed that FI was still higher in Bangladesh than in other developing countries such as Ethiopia (20.5%), Lebanon (55.2%), and Venezuela (50%) [27–29]. It was also much higher than in high-income countries such as the United States and Canada (16–17%) [25, 26], even though the FI measurement scale was different. In comparison to other studies conducted in Bangladesh, our findings indicate an overall prevalence of FI at 62.4%, which surpasses the moderate (46.6%) and severe (29.8%) FI prevalence reported by Yasmin et al. (2023) [16]. These disparities may be explained by differences in population variables (e.g., participant age, sampling, research schedule, cultural influences, economic environment, and study context), which may have contributed to the observed disparities. The increased prevalence of FI found in our study could also potentially be attributable to the COVID-19 pandemic. The pandemic's economic disruptions, including as job losses and reduced household income, are likely to have increased FI among Bangladeshi adolescents, leading to the higher prevalence observed in our sample.

The current study's high frequency of FI must be seen in light of the country's history and present circumstances. Bangladesh has seen several man-made and natural disasters that have compromised the food security of the poor and underprivileged since its independence in 1971 [43]. On a national scale, FI in Bangladesh can be directly connected to the country's history of political turmoil, climatic change, and international trade turbulence [43]. The prolonged relocation of about 1.1 million Rohingya refugees has placed a huge strain on Bangladesh's economy and infrastructure, potentially threatening food security [43]. Low income, acute poverty, insufficient access to roads, and distance to markets, particularly in rural Bangladesh, are constraints that limit households' ability to purchase food and physical access to food [43]. Furthermore, during the continuing COVID-19 pandemic, unemployment decreased income, and poverty has grown FI globally, including in Bangladesh [53]. All of these circumstances may have exacerbated

the economic difficulties and FI status of the country's most vulnerable households, particularly those with children.

The findings of our investigation revealed that males were more food insecure than females. This finding was consistent with earlier research [49], however, other investigations reported no difference [51, 54]. On the contrary, a report from Brazil showed that female adolescents were 1.60 times more likely to be food insecure than males [25]. Despite being reported from different nations, it was obvious that gender was deemed an identical factor for FI. One possible explanation for our findings is that boys have higher nutritional requirements than girls, resulting in a higher likelihood of experiencing or reporting FI [55]. In addition, research on high school students discovered that sex differences can be caused by social circumstances, as boys may try to protect their younger or female siblings by making sacrifices [55]. However, additional research is required to comprehend this connection properly.

The findings of this study, like those of other study [56], demonstrated a negative relationship between FI and the father's educational attainment. Another study from Portugal [49] showed a negative correlation between FI and the mother's education level. At the same time, research from Iran [29] and Lebanon [30] found a relationship between parental education level and FI in children. This may be explained by the fact that fathers typically provide the family's income. As a result, their lack of education may cause them to become unemployed and eventually fall into poverty. Another reason for the link between parental education and FI is that more educated parents are better able to provide for their children's dietary needs. Additionally, parents with formal education typically earn more money and are better able to give their children a healthy diet than other parents.

FI was particularly significant according to the monthly income of a family. The lower the income, the less secure the households' food security. According to our findings, medium or lower-income households were more likely to be food insecure. A similar thing was discovered in a study of Iranian schoolchildren [12]. Furthermore, children from low-income homes have been observed to be more likely to have FI [57]. Previous research supported our findings, confirming that poor income had a substantial influence on FI among teenagers [24, 29]. This could be due to lower or medium income reducing affordability and decreasing food purchasing capacity. As a result, families have limited access to food and financial resources. The findings of our study also revealed that household income perception was highly related to FI. This result agrees with the existing literature showing that adolescents perceiving insufficient household income were more likely to be food insecure [49].

This study possesses several strengths. It is the first study to investigate the prevalence and contributing factors of FI in a sample of adolescents from Bangladesh. Other advantages of the study include the use of a validated food security scale and a questionnaire that is sensitive to cultural differences. In addition, we evaluated FI based on reports from individual children rather than parent or caregiver reports, which may have a social desirability bias and make parents feel more embarrassed to report eating difficulties for their kids. This study increases our understanding of FI among youths in South Asia because there isn't much research on the topic.

4.1 Practical implications

- The findings of this study underscore the necessity for focused strategies to tackle FI among rural adolescents in Bangladesh, especially among males from low-income households.
- Effective approaches encompass initiatives aimed at economic empowerment, including activities that generate income for families and enhance educational access for parents, with the goal of alleviating FI.
- Furthermore, it is essential for policies to enhance food access for low-income households by implementing subsidies or direct assistance, while simultaneously tackling structural barriers such as insufficient infrastructure and limited market access in rural regions. Improving the education of parents, especially fathers, regarding nutrition and food budgeting may significantly reduce FI.
- From a policy perspective, government agencies like the Ministry of Health and Family Welfare (MoHFW), the Directorate General of Health Services (DGHS), and the Ministry of Food should include adolescent food security into their present nutrition and social safety net programs. Adolescents experiencing FI can benefit directly from targeted interventions including community-based nutrition education, food voucher programs, and subsidized school lunch programs.
- Gender sensitive interventions are also essential. Due to sociocultural issues, adolescent girls face unique challenges related to food access. In resource-constrained settings, policies should ensure that female adolescents' dietary requirements are met by implementing nutritional support programs that are specifically designed to address these barriers.
- It is crucial to adopt a multi-sectorial strategy, that involves the cooperation of the private sector, NGOs, institutions, and government agencies. Food production and affordilbility can be enhanced by strengthening partnerships with agricultural and rural development programs. Additionally, long-term behavioral adjustments among adolescents and their families can be facilitated by school-based nutrition initiatives, such as nutrition education curriculums and kitchen gardens.
- To reduce FI, clear policy suggestions should focus on increasing school feeding programs, subsidizing key food items for low-income households, and engaging NGOs in nutrition education initiatives.

4.2 Limitations

However, findings from the present study must be interpreted in light of certain limitations. We were only able to search for correlations between FI and socio-demographic characteristics because the study was cross-sectional, therefore, we could not investigate any potential causative associations. Future longitudinal studies will be necessary to explore causal relationships between FI and demographic factors in this population. The severity of FI detected at the household level may not exactly reflect how it was measured at the individual level. Our study had other limitations, including a small sample size and a focus on adolescents aged 12 years and older. The data cannot be generalized to non-student adolescents. Finally, the USDA Food Security Scale was not validated for Bangladeshi adolescents. Future study should focus on validating the scale for this group to guarantee its accuracy, cultural relevance, and suitability for evaluating FI among Bangladeshi adolescents.

5 Conclusions

Our research shows that more than half of all Bangladeshi adolescents experience FI, with the problem being more common among boys than girls. This requires quick attention from the government because measuring FI at the household level may obscure FI at the individual level, especially among adolescents. Practitioners and school counselors may utilize this knowledge to assist reduce FI in schools. Schools in high-poverty areas can introduce interventions like school-based food assistance programs, which include breakfast, lunch, and snacks to ensure that all students have access to nutritious food. School food banks or pantries might be established to provide free food to students in need. Adequate financial and other social support is required for adolescents to realize the promise of higher education as a tool for a better future. Focus groups, community conversations, and other qualitative evaluation approaches might be used to acquire a deeper understanding of the fundamental and underlying reasons for food poverty among adolescents. Consequently, it is vital to explore alternative efforts and policies to expand access to healthy meals and, more generally, to improve adolescents' economic stability so that they can concentrate on their education. We believe there needs to be further research into the cultural and social aspects of FI. We suggest conducting further research to better understand this phenomenon and develop context-specific interventions to lower FI and boost health in this population. To ascertain whether the percentage of FI is a constant across various geographic locations throughout the country, future research should make an effort to plan a more generalizable study that includes adolescents from various districts. Future research should take into account various higher education institutions, including both public and private universities.

Overall, by identifying the food security profiles of adolescents in two districts, this study made the first step toward addressing adolescent FI. The results show that FI among adolescents is significantly high. Future research should consider conducting longitudinal studies to track FI trends over time, examining how it affects academic performance, mental health, and long-term economic outcomes. Researchers and public health officials should start creating and putting into practice strategies to promote food security for adolescents as new research on the topic is completed.

Abbreviations

AOR	Adjusted odds ratios
BBS	Bangladesh Bureau of Statistics
BDT	Bangladeshi taka
COR	Crude/unadjusted odds ratios
FI	Food insecurity
GFSI	Global Food Security Index
IEC	Institutional Ethical Committee
PSTU	Patuakhali Science and Technology University
USDA	US Department of Agriculture
WFP	World Food Programme

Supplementary Information

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Additional file 1.

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Author contributions
M.N.I: conceptualization; methodology; data curation; investigation; visualization; writing—initial draft; writing—review and editing. F.K.M, M.A, M.R.A.S, and M.S.I: visualization; writing—revision and editing. S.E: methodology; data collection; data curation; visualization; writing—review and editing. S.M.I and S.D: methodology; data collection; data curation; visualization; writing—review and editing. N.R: conceptualization; methodology; data curation; formal analysis; investigation; application of software used in data analysis; supervision; validation; visualization; writing—initial draft; writing—revision and editing; project administration.

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Data availability
Data will be made available on reasonable request.

Declarations

Ethics approval and consent to participate
This study was conducted according to the guidelines laid down in the Declaration of Helsinki and all procedures involving research study participants were approved by the Institutional Ethical Committee (IEC) of the Patuakhali Science and Technology University, Bangladesh (Approval Number: PSTU/IEC/2022/37). Written informed consent was obtained from all subjects/patients.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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