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RESEARCH ARTICLE

Prevalence and socio-economic determinants of inadequate dietary diversity among adolescent girls and boys in Bangladesh: findings from a nationwide cross-sectional survey

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Abstract

Malnutrition among adolescents is often associated with inadequate dietary diversity (DD). We aimed to explore the prevalence of inadequate DD and its socio-economic determinants among adolescent girls and boys in Bangladesh. A cross-sectional survey was conducted during the 2018–19 round of national nutrition surveillance in Bangladesh. Univariate and multivariable logistic regression was performed to identify the determinants of inadequate DD among adolescent girls and boys separately. This population-based survey covered eighty-two rural, non-slum urban and slum clusters from all divisions of Bangladesh. A total of 4865 adolescent girls and 4907 adolescent boys were interviewed. The overall prevalence of inadequate DD was higher among girls (55·4 %) than the boys (50·6 %). Moreover, compared to boys, the prevalence of inadequate DD was higher among the girls for almost all socio-economic categories. Poor educational attainment, poor maternal education, female-headed household, household food insecurity and poor household wealth were associated with increased chances of having inadequate DD in both sexes. In conclusion, more than half of the Bangladeshi adolescent girls and boys consumed an inadequately diversified diet. The socio-economic determinants of inadequate DD should be addressed through context-specific multisectoral interventions.

Key words: Adolescent boys: Adolescent girls: Bangladesh: Inadequate dietary diversity

Introduction

Adolescence, the second decade of life, is the transition period from childhood towards adulthood and considered as a window of opportunity to build strong foundation for healthy and productive adulthood and consequently the health and wellbeing of the next generation[1–3]. In this era of fast demographic, epidemiological and nutritional transitions, adolescents are experiencing a complex burden of malnutrition worldwide[3,4]. In Bangladesh and other developing countries, adolescents are suffering from a very high prevalence of undernutrition, micronutrient deficiencies, overweight or obesity[5–8].

Poor diet, in terms of quantity and diversity, is one of the major causes of all forms of malnutrition at all stages of the life cycle. Evidence suggests that dietary diversity (DD), 'an increase in the variety of foods across and within food groups

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over a reference period'[9], reflects dietary quality in terms of nutrient adequacy of a diet at an individual level[10–15]. Food-based dietary guidelines recommend the intake of more diversified foods to address malnutrition and prevent diet-related chronic diseases[16,17].

Globally, adolescent diets are characterised by inadequately diversified food, less nutrient-dense food, more processed foods and beverages[2,18,19]. In low- and middle-income countries (LMICs), inadequate DD is more prevalent across all age groups due to the ubiquity of a large proportion of starchy staple in the whole diets[20–22] and similarly, in Bangladesh, the adolescent diets are poor in both diversity and micronutrient content[23–26]. Besides, systematic reviews show that in LMICs, a wide range of socio-economic determinants at the individual, parental, household, environmental and macro-system levels in different contexts influence the diversity and micronutrient contents of the diets among adolescents[19,27].

To date, only a limited number of studies have been conducted considering DD as the main outcome and explored factors associated with it among adolescents in Bangladesh. Moreover, these studies were mostly focused on girls[26–28], school-based adolescents[29] or pregnant adolescents[24,25]. These studies had small sample sizes and only a few studies focused on the determinants of inadequate DD[24,25,30]. None of these studies included adolescent boys as the study population. Therefore, population-weighted, nationally representative data are scarce on the prevalence of inadequate DD and its determinants among adolescent girls and boys. Given this reality, we intended to explore the national prevalence of inadequate DD and factors associated with inadequate DD among adolescent girls and boys in Bangladesh.

Methods

Study design and settings

Since 1990, the government of Bangladesh has been implementing nutrition and food security surveillance among women and children. In the 2018–19 round of the surveillance, we included additional population groups, for example, adolescent boys and girls, adult males and elderly people. In this survey, we covered all types of geographical areas, that is, rural, non-slum urban and slums from all eight administrative divisions of the country. We enrolled participants from eighty-two clusters (fifty-seven rural, fifteen non-slum urbans and ten slums) to generate divisionally and nationally representative estimates of different indicators, including the DD of adolescent boys and girls. Adolescents were interviewed after obtaining appropriate informed written assent and consent from the guardians (for 10 to <18 years old adolescents) and informed written consent (for ≥18 years old adolescents).

Sampling technique

Different sampling designs were employed to select study sites from rural, non-slum urban and slum areas and to draw a representative sample of Bangladesh. A four-stage sampling procedure was employed to select clusters in rural areas. First, two

districts were randomly selected from each of the eight divisions, and one sub-district was randomly selected from each of the selected districts. Then, two unions (the smallest administration unit) were randomly selected from each of the sub-district and were divided into segments with 250–400 households keeping the geographical demarcation of villages in the unions uninterrupted. Finally, two segments from each of the selected unions were randomly picked as the final data collection cluster (total 64).

In non-slum urban areas, sixteen wards (lowest administrative unit in the urban areas) from eight divisions were selected randomly. Then one *mahalla*/segment of 250–400 households was randomly picked from the list of *mahalla*/segments of each selected ward. Thus, a total of sixteen clusters (*mahalla*/segment) were selected from the urban areas, and data were collected from fifteen urban clusters. In slum settings, 'Census of Slum Areas and Floating Population 2014' were used to select the data collection clusters[31]. A total of ten slum clusters, each with ≥300 households from eight divisions (two from Dhaka and two from *Chattogram* and one from each remaining six divisions), were randomly selected.

Study participants and sample size

The sample size was calculated to obtain divisionally, nationally as well as slums representative prevalence estimates for the key variables of the study. For adolescents and other population groups, the prevalence (p) of key variables such as nutritional status and DD varied from 4 to 98 %. Considering the probability of Type I error, $\alpha = 0.05$; allowable margin of error, $d = 0.05$ or $p/2$ when $P \leq 0.1$; design effect, DEF = 1·61, sixty-two adolescent boys and sixty-two adolescent girls were needed from each cluster. Thus, the estimated sample size was 5580 for adolescent boys and 5580 for adolescent girls from 90 clusters. Due to an administrative embargo and financial constraints, data were finally collected from eighty-two clusters.

The data collection period of the study was from October 2018 to October 2019. In each cluster, all the households were listed to generate a sampling frame for each eligible participant from all six population groups (0–5 years old children, 10–19 years old adolescent girls, 10–19 years old adolescent boys, 20–59 years old women, 20–59 years old men and ≥60 years old persons). A total of 10 529 adolescent girls and 10 211 adolescent boys were listed from 25 371 households in 82 clusters and from them, 5084 boys (62 × 82) and 5084 girls (62 × 82) were randomly selected (62 girls and 62 boys from each cluster). If one household had more than one eligible participant from a population group, one of them was selected randomly. Five data collection teams, each comprising one supervisor and four to five data collectors, performed data collection and anthropometric measurements. As some of the randomly selected boys and girls were unavailable at home during the interview, and some refused the interviews, a total of 4907 adolescent boys and 4949 adolescent girls were enrolled in this survey. Among the adolescents, eighty-four girls were found pregnant during the data collection period. They were excluded from our

analysis as pregnancy may influence food consumption. Therefore, the final number of adolescent girls was in 4865.

Data collection techniques

We collected data using a structured questionnaire by face-to-face interviews. Physical measurements, height in cm (using locally made stadiometer) and weight in kg (using TANITA, model UM-070 weighing scale) of the adolescents were measured. Three measurements for height and three measurements for weight were taken over light clothing after confirming the privacy and comfort of the participants. All anthropometric measurements were taken based on WHO guidelines, as specified in the FANTA anthropometry manual[32]. Data were collected electronically using a customised SurveyCTO on a tablet computer (Samsung Galaxy Tab A7) application and were uploaded to the system every day at the end of data collection.

Quality control

Data collectors received a 5-d training on interview tools and techniques, physical measurements, calibration and maintenance of data collection instruments, and went through a standardisation process. Data collection questionnaires were pre-tested and modified based on the pre-test findings. About 5 % of the interviewed households were randomly re-interviewed, and another 5 % of the randomly selected interviews were observed by the supervisors to ensure data quality. Besides, interim analyses were done to check the quality of the data and we found that collected data had internal consistency and were in alignment with similar studies from Bangladesh.

Outcome variable

Our outcome variable of interest was inadequate DD among adolescent boys and girls. DD is an indicator of dietary intake at the individual level, which describes how diversified food a person consumes[13]. Minimum dietary diversity for women (MDD-W) is a population-level, simple and dichotomous indicator to assess DD at national and subnational levels[15,33,34]. The present study adopted the MDD-W questionnaire to collect dietary data using a list-based recall method on twenty-four food categories consumed in the last 24 h. These food categories were aggregated during analysis into the ten food groups ((1) grains, white roots and tubers and plantains; (2) pulses: beans, peas and lentils; (3) nuts and seeds; (4) dairy; (5) meat, poultry and fish; (6) eggs; (7) dark green leafy vegetables; (8) other vitamin A-rich fruits and vegetables; (9) other vegetables and (10) other fruits) following MDD-W guideline[33,34]. Regarding consumption of mixed dishes, we asked the respondents for all the ingredients included in that dish and record separately in the food list. We also considered the fact that whether the ingredient is usually consumed 'large enough' to be included as a separate food item or consumed usually very small amount to be classified as 'Condiments and seasonings' according to MDD-W

Table 1. Different categories/measurements of explanatory variables of the present study

Variables	Categories/measurements
Age	10–14 years, 15–17 years, 18–19 years
Education	No education, primary incomplete (grades 1–4), primary complete (grade 5), secondary incomplete (grades 5–9), secondary complete or higher (grades 10 or higher)
Nutritional status	Body mass index or BMI for age (BAZ): Thin (z-scores < -2SD), normal weight (≥ -2SD z-scores $\leq +1$SD), overweight and/or obese (z-scores $> +1$SD)
Maternal education	Same categories as for education level of adolescent
Paternal education	Same categories as for education level of adolescent
Place of residence	Rural, non-slum urban and slums
Religion	Islam, other than Islam (Buddhism, Christianity and Hinduism)
Household size	≤4 members, ≥5 members
Household headship	Male-headed, female-headed
Household food security status	Food secure, mildly food insecure, moderately food insecure, severely food insecure
Household wealth status	Poorest, poorer, middle, richer, richest

guideline[33,34]. We used the same tool to collect dietary data and the same cut-off point for adolescent girls as well as for boys to define inadequate DD since there is no separate tool available to measure DD among the boys. A girl or boy was categorised as having inadequate DD when s/he consumed foods from four or less food groups from the ten food groups in the last 24 h.

Explanatory variables

We carried out a literature review to identify the variables that can be the possible determinants of DD[24,25,30,35]. From our dataset, we identified the following variables age, education, nutritional status, maternal and paternal education, the place of residence, religion, household size, household headship, household food security status and household wealth status (Table 1). In our study, we collected individual-level information from the adolescents, and household head was the respondent for parental-level and household-level information.

We used the Household Food Insecurity Access Scale (HFIAS) questionnaire developed by the Food and Nutrition Technical Agency to collect data on behaviours and attitudes related to three domains of food insecurity (access) experiences including (1) anxiety and uncertainty about the household food supply; (2) insufficient food quality includes variety and preferences of the type of food and (3) insufficient food intake and its physical consequences to estimate the prevalence of food insecurity at the household level in Bangladesh[36]. Based on this guideline, we asked nine occurrence questions to the respondents on perceptions of their households' food vulnerability and on their behavioural responses to food insecurity with a recall period of 4 weeks (30 d) providing the options zero to three indicating frequency of the occurrence as never, rarely, sometimes and often, respectively. We used HFIA prevalence indicator to

categorises households into four levels of household food insecurity (access): food secure, and mild, moderately and severely food insecure.

For other variables of data collection, standard questions used by MEASURE DHS (Monitoring and Evaluation to Assess and Use Results Demographic and Health Surveys) for Demographic Health Surveys were followed[37]. For example, wealth index, a measure of relative wealth at the household level, was assessed through some specific assets, such as availability of amenities (electricity, solar electricity, radio, television, telephone, mobile, refrigerator, table/chair, watch/wall clock, almirah/wardrobe, electric fan, bicycle, motorcycle/motor scooter, car/truck, boat, water pump, etc.), household cooking fuel used (electricity, LPG, piped natural gas, kerosene, coal, wood, straw/grass/leaves, animal dung, bio-gas), main source of drinking water, type of toilet used, household materials of floor, walls and roof. All of these household characteristics and assets were analysed using principal component analysis. A composite wealth index was assessed using a DHS (Demographic and Health Survey) method consisting of area-specific indexes combined into a national model[37] The wealth index was divided into five quantiles. Categories for household size was done based on the national mean household size in Bangladesh, which is 4·5[37]. That's why we kept it as '≤4 members' and '≥5 members'. Regarding nutritional status, body mass index or BMI for age (BAZ) was calculated for adolescents using age- and gender-specific WHO growth charts in AnthroPlus software and adolescents were categorised as thin, normal weight and overweight and/or obese[38].

Statistical analysis

Descriptive analyses (frequency distribution and percentage) were performed to report socio-economic and demographic information of the adolescent girls and boys. Pearson's χ^2 test was administered using weighted data to estimate and compare the distribution of inadequate DD between boys and girls within different categories of each explanatory variable. All tests were two-tailed and a P-value of <0·05 was considered as statistically significant.

Binary logistic regression was done to assess the relationship of inadequate DD with each of the explanatory variables separately. The explanatory variables with P-value ≤0·2 in the univariate model were included in the final multivariable logistic regression model[39,40]. Multi-collinearity was checked using the 'correlation matrix' to identify the independent variables with higher correlation, and the variables with correlation coefficient ≥0·5 were excluded (age and paternal education: as these variables were highly correlated with educational attainment of adolescents and maternal education, respectively) before running the multivariable logistic regression. After considering P-value during univariate analyses and multi-collinearity, education, maternal education, place of residence, religion (only for boys), household headship, household food insecurity status and household wealth were included in the multivariable logistic regression model. The crude odds ratio (cOR), adjusted odds ratio (aOR) and 95 % CI of OR were

estimated, and a P-value of <0·05 was considered as statistically significant. All statistical analyses were performed using the statistical software package Stata (version 13.0).

Research ethics

Ethical approval from the Institutional Review Board (IRB) of the BRAC James P Grant School of Public Health, BRAC University, Dhaka, Bangladesh, was sought (reference number 2018-020-IR) before conducting the study. Community sensitisation meetings with local leaders and the representatives from potential respondents were done to get the community consent before stating data collection in an area. Written informed consent (assent for 10–17 years old adolescents and informed consents from their guardians) were taken prior to the interview. Privacy, confidentiality and anonymity were fully maintained throughout the research process.

Results

Background characteristics of the respondents

Table 2 outlines the detailed socio-economic and demographic characteristics of adolescent boys and girls. A higher proportion of the adolescent boys (56·8 %) and girls (54·9 %) belonged to the early adolescent group (10–14 years). In our study, the girls were better educated than boys. Regarding thinness, the proportion among boys was higher compared to the proportion among girls (28·5 % $v.$ 18·9 %). Approximately one in every ten adolescent boys and girls were overweight and/or obese (8·7 % $v.$ 10·5 %). Moreover, 42·4 % of households experienced any food insecurity, with 12·2 % households reporting severe food insecurity.

Socio-demographic distribution of inadequate DD among adolescents

The weighted prevalence of inadequate DD among adolescent boys and girls across the background characteristics is summarised in Table 3. The study revealed that, nationally, the prevalence of inadequate DD significantly ($P = 0·001$) varied by sex, and the prevalence was higher among girls (55·4 %) than boys (50·6 %). Although when adolescents were categorised in three age groups, the inadequate DD prevalence was significantly higher only among girls of 15–17 years age group compared to the boys of the same age (girls 58·5 % $v.$ boys 47·5 %, $P = 0·002$). The DD score for boys was higher than girls (4·49 ± 1·65 $v.$ 4·39 ± 1·61) and the overall score was 4·44 ± 1·63. A higher prevalence of inadequate DD was found among adolescents who had no education (68·6 %), were thin (54·7 %), lived in a slum (64·5 %), lived in a household with >4 members (54·7 %), and belonged to a female-headed household (58·0 %) compared to their respective counterparts. These findings were applicable for boys and girls separately, though the prevalence differed between girls and boys within the same variable categories in most cases. Regarding parental education, a lower prevalence of inadequate was observed among adolescents with highly educated mothers and fathers. Compared to adolescents from

Table 2. Distribution of adolescent boys and girls by socio-demographic characteristic

Characteristics	All adolescents (N 9772)		Adolescent boys (n 4907)		Adolescent girls (n 4865)	
	N	%[a]	n	%	n	%
Age group (years)						
10–14	5462	55·89	2789	56·84	2673	54·94
15–17	3026	30·97	1524	31·06	1502	30·87
18–19	1284	13·14	594	12·11	690	14·18
Educational attainment						
No education	219	2·24	161	3·28	58	1·19
Primary incomplete (grades 1–4)	2601	26·62	1518	30·94	1083	22·26
Primary complete (grade 5)	1376	14·08	658	13·41	718	14·76
Secondary incomplete (grades 6–9)	4322	44·23	1973	40·21	2349	48·28
Secondary complete or above (grade 10 or above)	1254	12·83	597	12·17	657	13·50
Nutritional status (BAZ)						
Thin	2315	23·69	1397	28·47	918	18·87
Normal	6519	66·71	3081	62·79	3438	70·67
Overweight and/or obese	938	9·60	429	8·74	509	10·46
Maternal education						
No education	3665	37·51	1835	37·40	1830	37·62
Primary incomplete (grades 1–4)	1260	12·89	633	12·90	627	12·89
Primary complete (grade 5)	1711	17·51	844	17·20	867	17·82
Secondary incomplete (grades 6–9)	2117	21·66	1081	22·03	1036	21·29
Secondary complete or above (grade 10 or above)	1019	10·43	514	10·47	505	10·38
Paternal education						
No education	4096	41·92	2026	41·29	2070	42·55
Primary incomplete (grades 1–4)	1041	10·65	532	10·84	509	10·46
Primary complete (grade 5)	1451	14·85	713	14·53	738	15·17
Secondary incomplete (grades 6–9)	1693	17·33	875	17·83	818	16·81
Secondary complete or above (grade 10 or above)	1491	15·26	761	15·51	730	15·01
Place of residence						
Rural	6828	69·87	3438	70·06	3390	69·68
Non-slum urban	1752	17·93	873	17·79	879	18·07
Slum	1192	12·20	596	12·15	596	12·25
Religion						
Islam	8530	87·3	4272	87·1	4258	87·5
Other than Islam[b]	1242	12·7	635	12·9	607	12·5
Household size						
≤4 members	5300	54·20	2725	55·5	2575	52·90
≥5 members	4472	45·80	2182	44·5	2290	47·10
Household headship						
Female-headed	2794	28·61	1405	28·65	1389	28·56
Male-headed	6973	71·39	3499	71·35	3474	71·44
Household food insecurity status						
Food secure	5627	57·61	2817	57·44	2810	57·78
Mild food insecurity	2460	25·19	1244	25·37	1216	25·01
Moderate food insecurity	493	5·05	248	5·06	245	5·04
Severe food insecurity	1187	12·15	595	12·13	592	12·17
Household wealth						
Poorest	1958	20·05	984	20·07	974	20·03
Poorer	1955	20·02	981	20·00	974	20·03
Middle	1953	20·00	981	20·00	972	19·99
Richer	1958	20·05	983	20·04	975	20·05
Richest	1943	19·89	975	19·88	968	19·91

[a] Column percentages.
[b] Buddhism, Christianity and Hinduism.

food-secured households, the prevalence of inadequate DD was observed higher among adolescents from households with any (mild to severe) food insecurity.

Determinants of inadequate DD among adolescents

The determinants of inadequate DD among adolescents and the strength of the association as revealed by crude and adjusted odds ratios are presented in Table 4 (for boys) and Table 5 (for girls). In the unadjusted analyses, education, maternal education, paternal education, place of residence, household headship, household food insecurity status, and household wealth were identified as significantly associated with inadequate DD among both boys and girls. Among these factors, education, maternal education, household headship, household food insecurity status, and household wealth were remained as significant predictors for inadequate DD after adjusting all the potential covariates in the final model for both boys and girls.

Table 3. Distribution of inadequate DD among adolescent boys and adolescent girls by socio-economic characteristics

Characteristics	Inadequate DD % [95 %CI]			P-value*
	All adolescents (*N* 9772)	Adolescent boys (*n* 4907)	Adolescent girl (*n* 4865)	
Overall	53·02 [47·28, 58·67]	50·63 [44·29, 56·95]	55·42 [50·03, 60·70]	0·001
Age group (years)				
10–14	53·08 [46·74, 59·33]	51·80 [44·63, 58·90]	54·40 [48·36, 60·31]	0·189
15–17	53·01 [47·07, 58·88]	47·54 [40·72, 54·46]	58·52 [51·75, 64·98]	0·002
18–19	52·69 [46·14, 59·15]	52·80 [44·61, 60·85]	52·58 [43·72, 61·29]	0·968
Educational attainment				
No education	68·62 [57·07, 78·26]	66·87 [53·46, 78·01]	77·22 [51·41, 91·57]	0·436
Primary incomplete (grades 1–4)	56·54 [48·02, 64·69]	54·76 [45·53, 63·68]	58·94 [50·55, 66·84]	0·086
Primary complete (grade 5)	47·88 [39·73, 56·14]	43·77 [33·16, 54·98]	51·99 [44·74, 59·17]	0·081
Secondary incomplete (grades 6–9)	53·53 [48·69, 58·31]	50·42 [44·59, 56·24]	56·09 [51·34, 60·72]	0·007
Secondary complete or above (grade 10 or above)	46·62 [39·73, 53·64]	44·45 [37·48, 51·64]	48·71 [40·18, 57·32]	0·259
Nutritional status (BAZ)				
Thin	54·65 [46·51, 62·54]	53·60 [44·26, 62·69]	56·25 [48·48, 63·73]	0·4294
Normal	52·63 [47·21, 57·99]	49·15 [43·40, 54·92]	55·73 [50·19, 61·13]	0·0001
Overweight and/or obese	50·90 [44·99, 56·79]	51·25 [41·97, 60·44]	50·64 [42·96, 58·30]	0·9216
Maternal education				
No education	54·12 [46·45, 61·59]	51·49 [42·63, 60·26]	56·85 [49·71, 63·71]	0·057
Primary incomplete (grades 1–4)	58·20 [51·21, 64·88]	55·39 [47·44, 63·08]	61·23 [53·71, 68·26]	0·085
Primary complete (grade 5)	51·90 [45·25, 58·48]	48·43 [40·86, 56·07]	55·21 [48·30, 61·92]	0·026
Secondary incomplete (grades 6–9)	53·07 [47·11, 58·95]	50·80 [43·74, 57·83]	55·32 [48·60, 61·85]	0·190
Secondary complete or above (grade 10 or above)	40·83 [34·37, 47·62]	41·70 [33·94, 49·90]	40·02 [30·82, 49·98]	0·781
Paternal education				
No education	53·84 [46·48, 61·04]	49·68 [41·64, 57·73]	57·90 [50·98, 64·53]	<0·001
Primary incomplete (grades 1–4)	58·98 [53·08, 64·64]	60·75 [52·68, 68·27]	57·03 [49·63, 64·13]	0·457
Primary complete (grade 5)	53·74 [46·20, 61·11]	51·64 [42·08, 61·08]	55·94 [48·91, 62·74]	0·276
Secondary incomplete (grades 6–9)	50·81 [45·10, 56·51]	46·02 [39·04, 53·17]	55·88 [49·07, 62·48]	0·016
Secondary complete or above (grade 10 or above)	46·27 [39·77, 52·91]	49·60 [41·01, 58·23]	43·18 [35·77, 50·90]	0·212
Place of residence				
Rural	53·00 [47·01, 58·90]	50·51 [43·92, 57·09]	55·51 [49·85, 61·03]	0·001
Non-slum urban	51·93 [40·74, 62·92]	52·41 [37·45, 66·95]	51·48 [42·24, 60·63]	0·855
Slum	64·54 [59·87, 68·95]	61·14 [57·14, 65·00]	67·80 [60·07, 74·66]	0·069
Religion				
Islam	52·90 [46·63, 59·07]	50·20 [43·15, 57·25]	55·59 [49·81, 61·23]	0·002
Other than Islam[a]	53·90 [47·08, 60·58]	53·71 [45·41, 61·81]	54·10 [46·63, 61·39]	0·922
Household size				
≤4 members	51·37 [44·92, 57·77]	48·92 [42·26, 55·62]	54·1 [47·27, 60·78]	0·011
≥5 members	54·65 [48·77, 60·40]	52·5 [45·77, 59·14]	56·61 [51·09, 61·97]	0·021
Household headship				
Female-headed	57·99 [51·61, 64·11]	57·48 [48·90, 65·63]	58·49 [52·65, 64·11]	0·778
Male-headed	51·41 [45·25, 57·53]	48·43 [41·92, 55·00]	54·43 [48·15, 60·57]	0·001
Household food security status				
Food secure	49·86 [43·76, 55·97]	47·38 [40·45, 54·41]	52·31 [46·57, 57·98]	0·011
Mild food insecurity	52·99 [45·06, 60·77]	51·64 [43·75, 59·44]	54·36 [45·70, 62·78]	0·259
Moderate food insecurity	68·32 [57·37, 77·56]	63·13 [47·20, 76·64]	73·70 [61·48, 83·10]	0·205
Severe food insecurity	61·48 [56·14, 66·56]	58·01 [52·01, 63·78]	65·28 [59·39, 70·73]	0·018
Household wealth				
Poorest	55·77 [47·71, 63·53]	55·54 [46·23, 64·48]	56·01 [47·19, 64·45]	0·911
Poorer	53·22 [45·36, 60·93]	50·12 [41·71, 58·52]	56·37 [48·60, 63·84]	0·011
Middle	57·23 [51·95, 62·35]	53·22 [46·74, 59·59]	60·96 [55·38, 66·28]	0·014
Richer	49·49 [43·10, 55·90]	43·43 [36·90, 50·19]	55·78 [48·59, 62·74]	0·000
Richest	46·28 [40·05, 52·62]	48·84 [41·48, 56·26]	43·73 [37·28, 50·40]	0·121

* *P*-value is between boys and girls of same variable categories.
[a] Buddhism, Christianity and Hinduism.

The chances of having inadequate DD had an inverse association with educational attainment among both boys and girls; however, the association was statistically significant only for those who had incomplete primary education (boys: aOR 1·41; 95 % CI 1·15, 1·71; *P* = 0·001 and girls: aOR 1·41; 95 % CI 1·15, 1·73; *P* = 0·001) and those who received no education (boys: aOR 1·78; 95 % CI 1·22, 2·58; *P* = 0·003 and girls: aOR 3·28; 95 % CI 1·65, 6·49; *P* = 0·001) compared to those who completed at least secondary level education.

Moreover, we found that maternal education has a highly significant inverse relationship with inadequate DD among both boys and girls. Meanwhile, boys belong to female-headed households had 26 % higher odds ratio (aOR 1·26; 95 % CI 1·10, 1·43; *P* < 0·001), and adolescent girl belonged to female-headed households had 21 % higher odds ratio (aOR 1·21; 95 % CI 1·06, 1·38; *P* = 0·004) to have inadequate DD in relation to adolescents from male-headed households. The chances of having inadequate DD among adolescents are relatively

Table 4. Multivariable logistic regression analysis on the socio-economic factors influencing inadequate DD among adolescent boys

Characteristics	Unadjusted			Adjusted[a]		
	cOR	95 % CI	P-value	aOR	95 % CI	P-value
Age group (years)						
10–14	1·00	0·84, 1·20	0·977	Not applicable		
15–17	1·02	0·84, 1·23	0·854			
18–19	1·00	Ref.	–			
Education						
No education	2·41	1·68, 3·47	<0·001	1·78	1·22, 2·58	0·003
Primary incomplete (grades 1–4)	1·65	1·36, 2·00	<0·001	1·41	1·15, 1·71	0·001
Primary complete (grade 5)	1·33	1·07, 1·66	0·012	1·16	0·93, 1·46	0·193
Secondary incomplete (grades 6–9)	1·24	1·03, 1·49	0·024	1·13	0·94, 1·37	0·196
Secondary complete or above (grade 10 or above)	1·00	Ref.	–	1·00	Ref.	–
Maternal education						
No education	2·46	2·01, 3·01	<0·001	1·88	1·5, 2·36	<0·001
Primary incomplete (grades 1–4)	2·53	1·99, 3·22	<0·001	1·98	1·53, 2·56	<0·001
Primary complete (grade 5)	2·27	1·81, 2·85	<0·001	1·84	1·45, 2·34	<0·001
Secondary incomplete (grades 6–9)	1·64	1·32, 2·04	<0·001	1·43	1·14, 1·8	0·002
Secondary complete or above (grade 10 or above)	1·00	Ref.	–	1·00	Ref.	–
Paternal education						
No education	1·86	1·57, 2·20	<0·001	Not applicable		
Primary incomplete (grades 1–4)	2·05	1·63, 2·56	<0·001			
Primary complete (grade 5)	1·58	1·29, 1·94	<0·001			
Secondary incomplete (grades 6–9)	1·25	1·03, 1·52	0·026			
Secondary complete or above (grade 10 or above)	1·00	Ref.	–			
Place of residence						
Rural	1·00	Ref.	–	1·00	Ref.	–
Non-slum urban	0·67	0·58, 0·78	<0·001	0·88	0·74, 1·05	0·147
Slum	1·06	0·89, 1·26	0·527	0·91	0·75, 1·09	0·296
Religion						
Islam	1·13	0·96, 1·34	0·139	1·09	0·91, 1·29	0·345
Other than Islam[b]	1·00	Ref.	–	1·00	Ref.	–
Household size						
≤4 members	1·00	Ref.	–	Not applicable		
≥5 members	1·04	0·93, 1·16	0·680			
Household headship						
Male-headed	1·00	Ref.	–	1·00	Ref.	–
Female-headed	1·25	1·10, 1·41	0·001	1·26	1·10, 1·43	<0·001
Household food security status						
Food secure	1·00	Ref.	–	1·00	Ref.	–
Mild food insecurity	1·49	1·30, 1·71	<0·001	1·28	1·12, 1·48	<0·001
Moderate food insecurity	2·6	1·96, 3·45	<0·001	2·07	1·55, 2·76	<0·001
Severe food insecurity	1·35	1·13, 1·61	0·001	1·10	0·92, 1·33	0·296
Household wealth						
Poorest	1·55	1·30, 1·86	<0·001	1·13	0·93, 1·38	0·215
Poorer	1·43	1·20, 1·71	<0·001	1·08	0·89, 1·32	0·429
Middle	1·58	1·32, 1·89	<0·001	1·23	1·02, 1·49	0·034
Richer	1·05	0·88, 1·25	0·608	0·92	0·76, 1·1	0·354
Richest	1·00	Ref.	–	1·00	Ref.	–

aOR, adjusted odds ratio; cOR, crude odds ratio; Ref., reference category.
[a] Adjusted for education, maternal education, place of residence, religion, household headship, household food security status and household wealth.
[b] Buddhism, Christianity and Hinduism.

higher for the food-insecure households compared to the food-secure household. Similarly, the girls of relatively poorer households had higher chances of having inadequate DD compared to the girls from the richest households. However, there was no such pattern among boys. No association was found either between the place of residence and inadequate DD or between religion and inadequate DD.

Discussion

Using nationally representative data from rural, non-slum urban and slum areas, this is the first study in Bangladesh to explore the prevalence of inadequate DD and its determinants among adolescent boys and girls. The findings of the study revealed that half of the adolescents in Bangladesh consumed less diversified diets, and girls were more likely to have inadequate DD than boys in all socio-economic categories. Poor educational attainment, poor maternal education, female household headship, household food insecurity and poor household wealth were identified as factors significantly associated with inadequate DD in both sexes.

Prevalence of inadequate DD

Our study revealed that in Bangladesh, more than half of the adolescent girls (55·5 %) consumed inadequately diversified

Table 5. Multivariable logistic regression analysis on the socio-economic factors influencing inadequate DD among adolescent girls

Characteristics	Unadjusted			Adjusted[a]		
	cOR	95 % CI	P-value	aOR	95 % CI	P-value
Age group (years)						
10–14	1·14	0·96, 1·35	0·130	Not applicable		
15–17	1·13	0·94, 1·35	0·184			
18–19	1·00	Ref.	–			
Education						
No education	4·84	2·47, 9·50	<0·001	3·28	1·65, 6·49	0·001
Primary incomplete (grades 1–4)	1·75	1·44, 2·13	<0·001	1·41	1·15, 1·73	0·001
Primary complete (grade 5)	1·39	1·13, 1·72	0·002	1·15	0·92, 1·43	0·214
Secondary incomplete (grades 6–9)	1·38	1·16, 1·64	<0·001	1·19	1·00, 1·43	0·053
Secondary complete or above (grade 10 or above)	1·00	Ref.	–	1·00	Ref.	–
Maternal education						
No education	2·33	1·91, 2·86	<0·001	1·67	1·34, 2·08	<0·001
Primary incomplete (grades 1–4)	2·15	1·70, 2·73	<0·001	1·63	1·27, 2·1	<0·001
Primary complete (grade 5)	1·95	1·56, 2·44	<0·001	1·53	1·21, 1·94	<0·001
Secondary incomplete (grades 6–9)	1·64	1·32, 2·04	<0·001	1·40	1·12, 1·75	0·003
Secondary complete or above (grade 10 or above)	1·00	Ref.	–	1·00	Ref.	–
Paternal education						
No education	2·21	1·86, 2·62	<0·001	Not applicable		
Primary incomplete (grades 1–4)	2·03	1·61, 2·55	<0·001			
Primary complete (grade 5)	1·58	1·28, 1·94	<0·001			
Secondary incomplete (grades 6–9)	1·45	1·18, 1·77	<0·001			
Secondary complete or above (grade 10 or above)	1·00	Ref.	–			
Place of residence						
Rural	1·00	Ref.	–	1·00	Ref.	–
Non-slum urban	0·67	0·58, 0·77	<0·001	0·92	0·78, 1·1	0·372
Slum	1·12	0·94, 1·34	0·203	1·04	0·86, 1·25	0·697
Religion						
Islam	1·09	0·92, 1·30	0·310	Not applicable		
Other than Islam[b]	1·00	Ref.	–			
Household size						
≤4 members	1·00	Ref.	–	Not applicable		
≥5 members	1·04	0·93, 1·17	0·700			
Household headship						
Male-headed	1·00	Ref.	–	1·00	Ref.	–
Female-headed	1·21	1·06, 1·37	0·004	1·21	1·06, 1·38	0·004
Household food security status						
Food secure	1·00	Ref.	–	1·00	Ref.	–
Mild food insecurity	1·54	1·34, 1·77	<0·001	1·31	1·14, 1·51	<0·001
Moderate food insecurity	2·39	1·79, 3·17	<0·001	1·93	1·44, 2·59	<0·001
Severe food insecurity	1·45	1·21, 1·73	<0·001	1·18	0·98, 1·42	0·085
Household wealth						
Poorest	1·91	1·60, 2·29	<0·001	1·43	1·17, 1·75	0·001
Poorer	1·83	1·53, 2·19	<0·001	1·41	1·15, 1·72	0·001
Middle	1·92	1·61, 2·30	<0·001	1·52	1·24, 1·85	<0·001
Richer	1·44	1·20, 1·72	<0·001	1·23	1·02, 1·48	0·027
Richest	1·00	Ref.	–	1·00	Ref.	–

aOR, adjusted odds ratio; cOR, crude odds ratio; Ref., reference category.
[a] Adjusted for education, maternal education, place of residence, household headship, household food security status and household wealth.
[b] Buddhism, Christianity and Hinduism.

diets, which is consistent with other studies in Bangladesh. One study conducted during 2017–18 in rural settings found that 53·0 % of adolescent girls had inadequate DD[35], which is close to our findings. However, this estimation is lower than the prevalence of inadequate DD among adolescent girls reported from an analysis using national-level databases of Bangladesh reported by Mridha *et al.* (60·4–65·3 % in 2014)[30] and another recent national-level survey among women aged 10–49 years[26]. Besides, results from several small-scale studies in Bangladesh also provided similar estimates though those studies were carried out among adolescent population groups in specific settings, for example, urban

slum, schools among pregnant adolescent girls[25,41,42]. This variation in inadequate DD prevalence within Bangladesh could be due to different methodological aspects such as food grouping, the number of food groups considered, various recall periods, types of the questionnaire (open recall or list-based method) used for data collection, etc., or contextual aspects like seasonality, geographical settings, etc., or might be due to different categories of study participants for different studies[33,35,43–45].

In our study, the prevalence of inadequate DD among adolescent boys (50·6 %) was lower than the adolescent girls. As per our knowledge, there is only one study[35] that reported the

prevalence of inadequate DD among the adolescent boys. Similar to our findings, the present study identified the lower prevalence of inadequate DD among boys than girls[35]. However, several studies in Bangladesh[23,46] and other countries reported dietary diversity score (DDS)[45,47,48], consumption of foods from individual food groups or inadequate intake at the nutrient level[23,46,49] among adolescent boys, which are not exactly comparable with our study results. A study in India[47] reported that among adolescents, DDS among boys was significantly higher (DDS = 4·5) compared to girls (DDS = 4·1), which in other way indicates higher inadequate DD among girls compared to boys and is similar to our findings. Less favourable dietary practices among adolescent girls compared to boys was also observed in Pakistan[50,51]. However, a longitudinal multi-country study reported that DDS among boys was slightly lower than adolescent girls in India, but this disparity was not statistically significant[45]. This higher prevalence of inadequate DD among girls compared to adolescent boys could be due to unequal allocation of food at the household level that advantaged the boys in the consumption of nutrient-rich foods along with other factors such as socio-cultural norms and malpractices as well as different dietary behaviours among girls than boys[45,52–56].

Determinants of inadequate DD

Education (adolescent and their parents). Our findings indicated that poor educational attainment of adolescents was a consistent and strong determinant of inadequate DD among adolescent boys and girls. The risk of having inadequate DD was significantly higher among adolescent boys and girls with no education or among those who did not complete primary education compared to those who had at least secondary level education. In most of the previous studies about the dietary intake of adolescents, the educational accomplishment of them was not examined as a predictor of their DD. However, a few studies in Bangladesh among pregnant adolescent girls[24,25] and women of reproductive ages[57] also found a positive association between education and DD. On the other hand, we did not find any research that analyzed the determinants of inadequate DD among adolescent boys. It is evident that a low level of food and nutrition literacy is associated with low DD among school-going children[58] but an understanding of how educational attainment affect diet quality require further exploration.

Since parents, particularly mothers, are the major decision-maker of adolescents' food intake, parental education, particularly maternal education is considered worthy of examining as an explanatory variable for adolescents' dietary intake[28–30,35,47]. Among boys and girls, our data suggested that lower maternal education, which in fact represents both maternal and paternal education (paternal education was highly associated with maternal education), was a significant predictor of inadequate DD. The existing literature indicates that for adolescents' (irrespective of sex) diet quality, maternal education level is a stronger predictor than the paternal education[29,47,59]. In urban Bangladesh, one study among school girls reported that

poor maternal education was associated with girls' intake of protein, fat and riboflavin[29]. Other studies among adolescent girls in Bangladesh and neighbouring countries frequently reported that low maternal education was associated with poor and less diversified diets and lower consumption of nutrient-rich foods[24,25,30,51]. Educated parents are more likely to have better nutritional knowledge and awareness and be economically better-off, which might be reflected in their children's diet quality and hence still demand further study.

Household headship. In our analyses, living in a female-headed household emerged as a significant factor that limits the diversity of diet among both boys and girls. In line with our findings, several studies reported that being part of female-headed households is associated with a poor diet in terms of quality and diversity at the individual and household levels[59,60]. On the contrary, there are studies from South Africa, Tanzania, Dominican Republic that reported female-headed households had a lower risk of inadequate DD at the household level compared to male-headed counterparts[61–63], which could be due to women' more involvement in food preparation, decision-making power on the household budget for high-quality diet, etc.[60,63].

Findings from our study support the conventional idea that female-headed households are more vulnerable to poor-quality diets at the individual level and also at the household level. Being a household head, a woman is responsible for earning income in the unfavourable labour market, maintaining the whole household, including childcare. As a result, they face a high dependency ratio, which makes the household and the individuals vulnerable to poor diet quality[57,64,65]. Besides the work burden, female-headed households face unique constraints concerning diet quality through low education, food insecurity and poverty[66]. Though we did not report the education of household heads, our study suggested that inadequate DD was also associated with different levels of food insecurity and low household wealth (see later).

Household food security status. We observed that compared to adolescents from food-secure households, adolescents from mild and moderate food-insecure households had a significantly higher risk of having inadequate DD. Our result supports previous studies conducted among adolescents girls[30,35] and among women of reproductive age in Bangladesh[67]. Moreover, a study found that food insecurity status is linked with lower consumption of animal source foods, vitamin C-rich fruits and vegetables among pregnant adolescent girls[24]. It is already established that household DD reflects household food security, and a considerable association was found between individual level DD and household food security[10,13,68,69]. Besides, evidence suggests that the three pillars of food security, that is, availability, accessibility and utilisation[61,70,71] are associated with DD.

Household wealth status. Our data suggested that adolescent girls and boys from poor households were more

likely to have inadequate DD compared to the girls from the wealthiest households. Similar findings have been observed in many other studies in Bangladesh. Different studies reported that poor asset quintile[30], low socio-economic status[24,29,35], low household expenditure[23], low income[25,59], low wealth score[57] increased the risk of having inadequate DD among adolescents and women compared to their counterparts. A close look at the ten food groups of DD score, where fruits and vegetables were included in four groups, and animal source foods covered another three groups, could be helpful to explain this association. The consumption of fruits and vegetables along with animal source foods increases with income in Bangladesh like many other developing countries[22,24,72]; hence poor households cannot afford the animal source foods in the first place. Besides, poor household members prioritise fulfilling the basic energy requirement from staples foods to get rid of hunger within their budget allocation for foods[9]. Moreover, the lack of knowledge about the health benefits of vegetables and fruits and the personal preference of adolescents from poor households limits the consumption too[9,72]. Thus, lower economic conditions act as a risk factor for inadequately diversified diets among adolescents.

Strengths and limitations

The present study has several strengths over other studies of this kind. Firstly, the present study used the latest national-level survey dataset, covering rural, non-slum urban and slum areas and collected at the community level. Thus, the results of the present study could be generalised to the entire adolescent population. Secondly, for the first time in Bangladesh, adolescent boys were included for a comprehensive assessment of their dietary practices, which is a timely response to the urgency of gender-segregated data on the diets of adolescents. Lastly, previous studies on DD mostly used DDS as a measure of diversified diets, but there were no clear cut-off points to define as 'adequate' of 'inadequate' DD, which was crucial for advocacy and to take public health actions[57]; our study will serve this purpose perfectly. Based on the findings of the present study, national policies and programmes could be designed to address inadequate DD among adolescent boys and girls who need it most, considering the identified determinants and their socio-economic stratification.

However, our study has some limitations too. 'We had to drop several rural clusters due to some administrative and financial hurdles which might have affected the representativeness of the study'. As the data source of the present study is a cross-sectional survey, it must be acknowledged that associations were estimation and causality cannot be determined from these findings. Besides, there are many other sets of explanatory variables omitted from the model that may have predictive power on inadequate DD among adolescents such as behavioural, cultural and environmental, here we just considered the socio-economic factors. More research must be done to understand better how these factors employ their impact on diet among adolescents, particularly since the variance in the outcome variable was largely unexplained. Besides,

all dietary data were self-reported, and it is evident that dietary recall in adolescents affected by lack of motivation and willingness, and thus, assessment of dietary intake of adolescents can be subject to underreporting and misreporting[44,73,74]. It may have exaggerated responses non-randomly across the study participants. Moreover, we used a list-based recall method for dietary data collection in the last 24 h only, which tends to provoke biased towards socially desirable responses, such as untrue positive responses for high-status foods (e.g. meat) compared to the open recall method. Besides, a single 24 h recall has its own limitation regarding inability to capture day-to day variation.

Conclusion

We found that more than half of the adolescent boys and girls consume inadequately diverse diets in Bangladesh, and the prevalence of inadequate DD was higher among girls than boys. Our study also identified that a number of socio-economic risk factors such as lower educational level of adolescents and their parents, living in female-headed, food insecure and poor households were associated with inadequate DD among adolescent boys and girls in Bangladesh. These findings have manifold operational and policy implications for improving adolescents' DD in resource-poor countries like Bangladesh. Gender disparity and socio-economic inequity of adolescents' DD emerged from the present study should be addressed through policy interventions. At the household level, broader poverty alleviation initiative, particularly for female-headed households, is necessary to address inadequate DD among adolescents through improving households' economic and food security status, which will, in turn, enable households' accessibility to nutrient-rich diversified foods. Hence, investing in adolescents would be the best utilisation of resources not only for the betterment of adolescents themselves but for the future generations.

F. A. conceptualised and drafted the initial manuscript. M. M. H. conducted the data analysis. A. A. S., M. S. A. K., M. H., A. A. M. H., M. He., N. J. U., M. A. U., S. K. S., S. M. M. R., D. K. M. and M. M. I. B. were involved in the conceptualisation and design of the study as well as reviewed and approved the final version of the manuscript. M. K. M. led the design and implementation of the whole research project, approved the data analysis plan, critically reviewed the manuscript and approved the final manuscript. All authors read and approved the final version of the manuscript.

The authors declare that they have no conflict of interest.

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