PLOS ONE

RESEARCH ARTICLE

Poverty and childhood malnutrition: Evidence-based on a nationally representative survey of Bangladesh

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Citation: Rahman M.A, Halder HR, Rahman M.S, Parvez M (2021) Poverty and childhood malnutrition: Evidence-based on a nationally representative survey of Bangladesh. PLoS ONE 16(8): e0256235. https://doi.org/10.1371/journal.pone.0256235

Editor: Madhavi Bhargava, Yenepoya Medical College, Yenepoya University, INDIA

Received: March 29, 2021

Accepted: August 3, 2021

Published: August 23, 2021

Data Availability Statement: This study used publicly available Demographic and Health Surveys Program datasets from Bangladesh which can be freely obtained from https://dhsprogram.com/.

Funding: The author(s) received no specific funding for this work.

Competing interests: The authors have declared that no competing interests exist.

Abstract

Background

Malnutrition contributes to children's morbidity and mortality, and the situation undermines the economic growth and development of Bangladesh. Malnutrition is associated with lower levels of education that decrease economic productivity and leads to poverty. The global burden of malnutrition continues to be unacceptably high amid social and economic growth, including in Bangladesh. Therefore, identifying the factors associated with childhood malnutrition and poverty is necessary to stop the vicious cycle of malnutrition leaded poverty.

Methods

The study utilized the 2017–18 Bangladesh Demographic and Health Survey (BDHS), accumulating 7,738 mother-child pairs. Associations between potential risk factors and nutritional status were determined using chi-square tests, and multivariate logistic regression models were utilized on significant risk factors to measure their odds ratio (OR) with their 95% confidence intervals (CI).

Results

The prevalence of moderate and severe wasting was 7.0% and 1.8%, respectively, whereas the prevalence of moderate and severe stunting was 19.2% and 8.0%, while 16.4% and 3.6% of children were moderately and severely underweight. Children from the poorest and poor households were suffering from at least one form of malnutrition. Adjusted ORs were estimated by controlling socio-economic and demographic risk factors, such as poor maternal body mass index, parents' lower education level, use of unhygienic toilet, child age in months, and recent experience of diarrhea and fever. The pattern was almost similar for each malnutrition status (i.e., stunting, underweight, and wasting) in the poorest and poor households.

Conclusion

Bangladesh achieved the Millennium Development Goals, focusing primarily on health-related indicators and working to achieve the Sustainable Development Goals. Even considering this success, the prevalence of malnutrition and poverty in same household remains relatively high compared to other developing countries. Therefore, the study recommends the implementation of nationwide systematic measures to prevent poverty and malnutrition.

Background

Worldwide, childhood malnutrition is a significant public health concern as it contributes to impaired mental and physical growth and is a significant cause of child morbidity and mortality [1–3]. Around 3.5 million children die every year from malnutrition, and low- and middle-income countries (LMICs) are more prevalent, advancing the global burden of diseases by 11% [4]. Furthermore, the 2021 joint report of childhood malnutrition by the United Nations Children's Fund, World Health Organization (WHO), and World Bank Group found that 149 and 45.4 million children under age five in 2020 were stunted and wasted [5].

Poverty and childhood malnutrition are believed to be interlinked [6], which is mediated by inadequate diet plan, lower education level, poor living standards, and lack/no access to health facilities, safe water, proper sanitation and hygiene [6, 7]. Hence, developing countries, including Bangladesh, prioritize reducing poverty and childhood malnutrition by various policy implications. Besides, a poorly nourished child has a greater likelihood of being less productive in his/her adulthood, adversely impacting the economy in the long run [8]. Therefore, proper nutrition in childhood is the foremost need as it increases their survival probability and ensures a better economy of a country.

As the effects of childhood malnutrition are intergenerational, public policies and poverty reduction strategies have targeted multi-faceted approaches in developing countries [7, 9]. Bangladesh has already initiated several of these approaches despite accounting for their effectiveness, such as nutritional programs (i.e., food for education and nutrition), education for poverty reduction [1, 2, 7, 9]. Moreover, the Poverty Reduction Strategy Paper (PRSP) of Bangladesh designed various plans to achieve strategic and employment growth, implementing macroeconomic structure in public and private sectors. The PRSP plan that includes strategic human resources development aims to reach the poor and vulnerable population for the protection of the environment, climate change, and disaster management [10]. Over the past fifteen years, Bangladesh has succeeded in reducing childhood malnutrition, but substantial inequalities exist across geographical regions and economic groups [8, 11]. According to 2014 [12] and 2017–18 [13] Bangladesh Demographic and Health Survey (BDHS), children from the lowest quintile were most prevalent in stunting, wasting, and underweight; whereas, the scenario is the total opposite for the highest quintile.

Many studies have documented the relationship between childhood malnutrition and wealth quintiles-based measures utilizing Demographic Health Surveys (DHS) data, demonstrating that childhood malnutrition is still higher in the poor quintile than the non-poor counterparts [7, 14–16]. However, apart from economic factors, many non-economic factors (such as place of residence, geographical locations, access to water and sanitation, maternal and child-related biological characteristics, etc.) are also regarded as important determinants of childhood malnutrition at the household level [1–3, 7, 17, 18]. To promote health equity

and equitable gains, policymakers and development professionals strongly emphasize reducing this economic gap to have a more significant impact on childhood malnutrition [19].

In light of the discussion, it is essential for the government and development partners to carefully examine and identify the significant determinants of childhood malnutrition and its linkage to poverty [19]. However, only a few studies have focused on the determinants linked to this issue. This research will allow the government and development practitioners to curate strategic decisions, reduce the prevalence of childhood malnutrition, and design and follow-up effective actions for both conditions.

Methods

Data sources

The study used the 2017–18 BDHS data, which is freely available upon request. The survey was conducted between October 2017 and March 2018 under the National Institute of Population Research and Training, Medical Education and Family Welfare Division, and Ministry of Health and Family Welfare to assess health indicators and provide a detailed overview of the Bangladeshi population, and maternal and child health-related issues. A total of 7,738 mother-child pairs' information was assessed in the current study. Detailed survey information (such as data collection procedures, sample size determination, etc.) was described in the BDHS 2017–18 report [13]. The study included ever-married women aged 15–49 with valid body mass index (BMI) who are currently not pregnant and gave birth to at least one child preceding the survey. Unmarried and not pregnant mothers with incomplete BMI information were excluded from the sample. A total of 20,127 ever-married women aged between 15 and 49 years were interviewed out of 20,376 eligible women [13]. Only 7,762 participants gave birth to children, and there were 24 missing values among them. We excluded the missing values from our analyses, making the total number of observations 7,738 (Fig 1).

Study variables

Dependent variables. We used three dependent variables for this study: stunting, underweight, and wasting. Dependent variables were classified based on Z-scores of height-for-ages

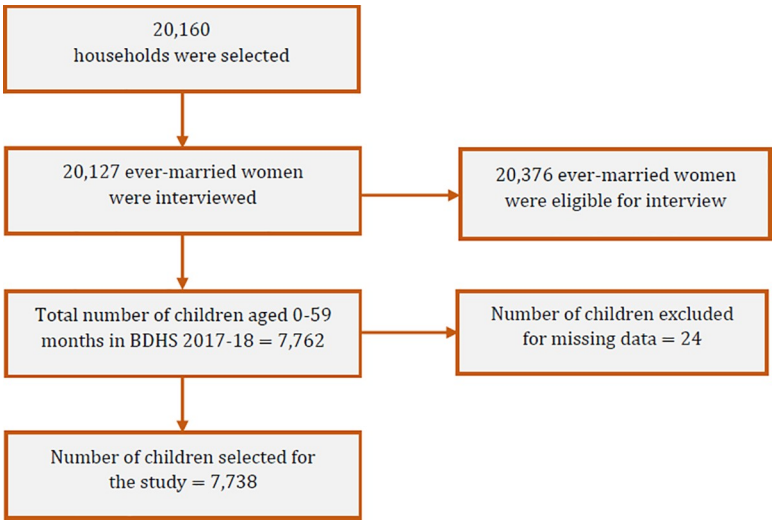

Fig 1. Sampling flowchart for the selection of participants.

https://doi.org/10.1371/journal.pone.0256235.g001

(HAZ) for stunting, weight-for-height (WHZ) for wasting, and weight-for-age (WAZ) for underweight. WHO Anthro Plus (version 3.2.2) was used to calculate the Z-scores and they were categorized either as nourished (Z-score ≥ -2.0), moderately stunted/underweight/wasted ($-3.0 \leq$ Z-score < -2.0), or severely stunted/underweight/wasted (Z-score < -3.0) following WHO Child Growth Standards guideline [20]. In this study, a small number of children were severely malnourished; therefore, moderate and severe malnutrition were merged into one. The outcome variables used in this study are stunting, underweight, and wasting (coded 1 = presence of the condition, otherwise 0).

Independent variables. The study analyzed independent variables from prior literature, which included three main categories: socioeconomic and demographic characteristics, child-related determinants, and paternal characteristics. Socioeconomic and demographic characteristics involved: division (Barisal, Chittagong, Dhaka, Khulna, Mymensingh, Rajshahi, Rangpur, Sylhet); place of residence (urban, rural); drinking water source (unimproved, improved); type of toilet (unhygienic, hygienic); place of childbirth (facility birth, home delivery) [21, 22]. Child-related determinants included birth order (1^{st}, 2^{nd}, 3^{rd}, $\geq 4^{th}$); age in months (0–5, 6–11, 12–23, 24–35, 36–59); sex (male, female); experience of diarrhea and fever two weeks preceding the survey (no, yes). Furthermore, paternal factors consist of maternal BMI (underweight: $<18.50 kg/m^2$, normal: $18.50–24.99 kg/m^2$, overweight/obese: $\geq 25.00 kg/m^2$) based on the global cut-off points [23]; maternal age in years (15–24, 25–34, 35–49); maternal age at first birth (<18, 19–24, ≥ 25); parental education (no education, primary, secondary, higher); mother's current working status (no, yes); mother's exposure to television (no, yes); mother's antenatal care (ANC) visit number (Nil, 1–3, ≥ 4); father's occupation (agricultural, business, non-agricultural, other). Household wealth status was originally categorized into five groups based on principal component analysis, which was then recoded into three groups: poorest, poor, and well-off (consisted of medium, richest, and richer).

Statistical analyses

Before conducting any statistical analyses, we weighted the dataset due to the cluster sampling design of DHS. Then, we reported descriptive statistics (i.e., frequency and percentage) and weighted prevalence with their 95% confidence intervals (CIs) of selected independent variables. Pearson's chi-square test of independence examined the relationship between dependent and independent variables. We implemented multivariate logistic regression models to estimate the adjusted odds ratios (AORs) and their 95% CIs for stunting, underweight, and wasting segregated by wealth status (i.e., poorest, poor, and well-off). Besides, all confounding variables were controlled while multivariate modeling, and we examined multicollinearity among independent variables by applying the variance inflation factor. All data analyses were performed using the Statistical Package for Social Science (SPSS) version 25 (SPSS Inc., Chicago, USA) and R version 4.0.2 (Bell Laboratories, New Jersey, USA).

Ethical consideration. DHS data exists in the public domain and is freely accessible upon reasonable request. The Ethics Committee of Bangladesh and ICF international approved the study protocol; therefore, we did not require further ethical approval. Details of the ethical approval can be found in the BDHS 2017–18 summary report [13].

Results

Table 1 exhibits the univariate results of socioeconomic and demographic, parental, and child-related characteristics from 7,738 children aged under five years. 7% and 1.8% of children were moderately and severely wasted, whereas moderate and severe stunting percentages were 19.2% and 8.0%, respectively. Results also showed, 16.4% and 3.6% of children were

Table 1. Frequency distribution of background characteristics for study participants (n = 7,738).

Background Characteristics		Total n (%)	Poorest n (%)	Poor n (%)	Well-Off n (%)
Child-related Characteristics					
Malnutrition					
	Moderate Wasting	538 (7.0)	139 (8.2)	111 (7.0)	288(6.4)
	Severe Wasting	142 (1.8)	33 (2.0)	27 (1.7)	82(1.8)
	Moderate Stunting	1484 (19.2)	408 (24.2)	387 (15.4)	689(15.4)
	Severe Stunting	619 (8.0)	207 (12.3)	140 (8.9)	277(6.1)
	Moderate Underweight	1265 (16.4)	364 (21.6)	290 (18.3)	611(13.7)
	Severe Underweight	276 (3.6)	91 (5.4)	70 (4.4)	115(2.6)
Birth Order					
	1^{st}	2930 (37.9)	493 (29.2)	547 (34.6)	1890(42.3)
	2^{nd}	2535 (32.8)	517 (30.6)	522 (33.0)	2535(32.8)
	3^{rd}	1310 (16.9)	327 (19.4)	286 (18.1)	1310(16.9)
	$\geq 4^{th}$	961 (12.4)	350 (20.7)	226 (14.3)	961(12.4)
Age (months)					
	0–5	913 (11.8)	193 (11.4)	178 (11.3)	542(12.1)
	6–11	789 (10.2)	169 (10.0)	185 (11.7)	435(9.7)
	12–23	1612 (20.8)	331 (19.6)	342 (21.6)	939(21.0)
	24–35	1507 (19.5)	328 (19.4)	301 (19.0)	878(19.7)
	36–59	2916 (37.7)	668 (39.6)	575 (36.4)	1673(37.5)
Sex					
	Male	4047 (52.3)	885 (52.5)	826 (52.3)	2336(52.3)
	Female	3688 (47.7)	802 (47.5)	754 (47.7)	2132(47.7)
Recent Experience of Diarrhea[†]					
	No	7360 (95.2)	1606 (95.2)	1505 (95.3)	4249(95.1)
	Yes	375 (4.8)	81 (4.8)	75 (4.7)	219(4.9)
Recent Experience of Fever[†]					
	No	5129 (66.3)	1099 (65.1)	1047 (66.3)	2983(66.8)
	Yes	2606 (33.7)	588 (34.9)	533 (33.7)	1485(33.2)
Socio-economic and Demographic Characteristics					
Division					
	Barisal	435 (5.6)	156 (9.2)	105 (6.6)	174(3.9)
	Chittagong	1601 (20.7)	296 (17.5)	276 (17.5)	1029(23.0)
	Dhaka	1925 (24.9)	203 (12.0)	243 (15.4)	1479(33.1)
	Khulna	724 (9.4)	107 (6.3)	161 (10.2)	456(10.2)
	Mymensingh	660 (8.5)	207 (12.3)	189 (12.0)	264(5.9)
	Rajshahi	901 (11.6)	193 (11.4)	230 (14.6)	478(10.7)
	Rangpur	842 (10.9)	334 (19.8)	225 (14.2)	283(6.3)
	Sylhet	648 (8.4)	192 (11.4)	150 (9.5)	306(6.8)
Place of Residence					
	Urban	2040 (26.4)	185 (11.0)	133 (8.4)	1722(38.5)
	Rural	5695 (73.6)	1502 (89.0)	1447 (91.6)	2746(61.5)
Drinking Water Source					
	Unimproved	83 (1.1)	24 (1.4)	31 (2.0)	28(0.6)
	Improve	7654 (98.9)	1664 (98.6)	1550 (98.0)	4440(99.4)
Type of Toilet					
	Unhygienic	2165 (28.0)	1018 (60.3)	679 (43.0)	468(10.5)
	Hygienic	5571 (72.0)	670 (39.7)	901 (57.0)	4000(89.5)

(*Continued*)

Table 1. (Continued)

Background Characteristics		Total n (%)	Poorest n (%)	Poor n (%)	Well-Off n (%)
Place of Childbirth					
	Facility Birth	2398 (49.7)	270 (26.5)	373 (37.1)	1755(62.7)
	Home Delivery	2425 (50.3)	750 (73.5)	633 (62.9)	1042(37.3)
Parental Characteristics					
Maternal BMI					
	Underweight (<18.50kg/m^2)	1074 (13.9)	356 (21.1)	283 (17.9)	435(9.7)
	Normal (18.50–24.99kg/m^2)	4680(60.5)	1128(66.8)	1057(66.9)	2495(55.8)
	Overweight/Obese (≥25.00kg/m^2)	1983 (25.6)	204 (12.1)	241 (15.2)	1538(34.4)
Maternal Age (years)					
	15–24	3687 (47.7)	784 (46.5)	812 (51.4)	2091(46.8)
	25–34	3472 (44.9)	767 (45.5)	652 (41.2)	2053(45.9)
	35–49	577 (7.5)	136 (8.1)	117 (7.4)	324(7.3)
Maternal Age at First Birth (years)					
	<18	4532 (58.6)	1194 (70.7)	1060 (67.0)	2278(51.0)
	19–24	2844 (36.8)	466 (27.6)	488 (30.9)	1890(42.3)
	≥25	361 (4.7)	28 (1.7)	33 (2.1)	300(6.7)
Mother's Education					
	No Education	542 (7.0)	243 (14.4)	117 (7.4)	182(4.1)
	Primary	2214 (28.6)	795 (47.1)	563 (35.6)	856(19.2)
	Secondary	3790 (49.0)	604 (35.8)	810 (51.2)	2376(53.2)
	Higher	1192 (15.4)	46 (2.7)	91 (5.8)	1055(23.6)
Mother's Current Working Status					
	No	4640 (60.0)	779 (46.2)	801 (50.7)	3060(68.5)
	Yes	3098 (40.0)	908 (53.8)	780 (49.3)	1408(31.5)
Mother's Exposure to Television					
	No	2868 (37.1)	1268 (75.2)	750 (47.4)	850(19.0)
	Yes	4868 (62.9)	419 (24.8)	831 (52.6)	3618(81.0)
Mother's ANC Visit Number					
	Nil	3478 (45.0)	881 (52.2)	722 (45.7)	1875(42.0)
	1–3	2061 (26.6)	505 (29.9)	503 (31.8)	1053(23.6)
	≥4	2197 (28.4)	302 (17.9)	355 (22.5)	1540(34.5)
Father's Education					
	No Education	1176 (15.2)	524 (31.1)	297 (18.8)	355(7.9)
	Primary	2677 (34.6)	792 (46.9)	729 (46.1)	1156(25.9)
	Secondary	2556(33.0)	314(18.6)	457(28.9)	1785(40.0)
	Higher	1327 (17.20)	57 (3.4)	98 (6.2)	1172(26.2)
Father's Occupation					
	Agricultural	1589 (20.5)	626 (37.1)	445 (28.1)	518(11.6)
	Business	1649 (21.3)	203 (12.0)	268 (17.0)	1178(26.4)
	Non-Agricultural	3533 (45.7)	523 (31.0)	636 (40.2)	2374(53.1)
	Other	967 (12.5)	336 (19.9)	232 (14.7)	399(8.9)

† Recent experience indicates sufferings from diarrhea and fever two weeks preceding the survey.

BMI: Body mass index; ANC: Antenatal care.

https://doi.org/10.1371/journal.pone.0256235.t001

moderately and severely underweight. More than half (52.3%) of the children were male, the majority (73.6%) were from rural areas, almost one-fourth (24.9%) were from Dhaka, and about 7.0% of mothers and 15.2% of fathers had no formal education.

Table 1 also portrays the frequency and percentage of selected background characteristics for under-five children segregated by household wealth status. All forms of child malnutrition (i.e., wasting, stunting, and underweight) peaked in the poorest households and the lowest in well-off families. Poorest households had more frequency of underweight mothers, whereas overweight/obese mothers were more frequent in well-off families. More than 70% of mothers who gave their first birth before 18 years were from the poorest families, while the percentage was much lower in poor (67.0%) and well-off (51.0%) households. Percentages of parents with secondary and higher education, access to hygienic toilets, and facility birth were considerably higher in well-off families compared to their poorest and poor counterparts. Mothers' ANC visit number also increased with better household status.

Table 2 shows the prevalence of wasting, stunting, and underweight by the selected characteristics of under-five children with their 95% CIs. Results show that the prevalence of all forms of malnutrition (i.e., wasting, stunting, and underweight) was the highest in Sylhet division, poorest households, and underweight, illiterate mothers aged between 35 and 49 years. Mothers' first birth age of $<$18 years, lack of exposure to television, households with unimproved water, and unhygienic toilet facilities also had a higher prevalence for all forms of malnutrition. The prevalence of wasting, stunting, and underweight was the highest amongst male children, children born at home, and who had recent experience of fever. Moreover, the prevalence of wasting was the highest among children aged below six months. While 24–35 and 36–59 months aged children were more prevalent in stunting and underweight, receptively.

Table 3 represents associated factors of stunting segregated by household wealth status. The result indicated that underweight mothers significantly affected the poorest and poor households due to higher ORs. Poorer households showed a significant association of stunting with division, indicating a greater likelihood of stunted children in Chittagong (1.16 folds higher than Sylhet). However, maternal age at first birth was not significantly associated with stunting among various household wealth statuses. Paternal education greatly impacted poor and rich households (2.94 and 1.98 times more than higher education levels), which resulted in stunted children. The odds of stunting were higher in rich households for fathers with non-agricultural services and business. In poorer households, 1^{st}, 2^{nd}, and 3^{rd} birth order children had a lower odds of being stunted when compared to $\geq 4^{th}$ birth order. Children's age significantly affected all households; for example, the likelihood of stunting was higher for children aged 36 to 59 months in the poorest and poor families, but odds were lower in well-off families. Low maternal BMI was significantly associated with increased stunting for the poorest and poor compared with well-off families.

Table 4 visualizes children's odds of being underweight by household wealth statuses (i.e., poor, poorer, and well-off). Results implied that maternal BMI significantly affected all wealth statuses. For instance, if a mother was underweight, there was a higher likelihood of the child being underweight. Besides, illiterate parents from the poorest and poor households had higher chances to have an underweight child. In poorest households of Dhaka and Barisal, there was a greater chance for a child being underweight, but the likelihood was higher for poor households in Mymensingh. Furthermore, maternal age, mother's exposure to television, drinking water source, type of toilet, mother's ANC visit number, child's birth order, place of childbirth showed insignificant association with underweight within different wealth statuses.

Factors associated with wasting within different categories of wealth statuses are reported in Table 5. It was evident from the results that only poor households had a higher risk of having wasted children when the mother was underweight. However, mother's education, type of

Table 2. Prevalence of malnutrition by background characteristics with 95% confidence interval (n = 7,738).

Independent Variables		Wasting (95% CI)	Stunting (95% CI)	Underweight (95% CI)
Child-related Variables				
Birth Order				
	1st	8.7 (7.5–10.1)	25.0 (23.1–26.9)	17.9 (15.3–19.6)
	2nd	8.9 (7.7–10.3)	25.0 (22.9–27.3)	18.8 (17.1–20.7)
	3rd	8.9 (7.4–10.7)	28.8 (26.0–31.7)	20.5 (18.2–23.0)
	≥4th	8.3 (6.6–10.4)	37.4 (33.9–41.1)	28.2 (24.8–31.8)
Age (months)				
	0–5	10.2 (8.1–12.9)	10.5 (8.4–13.1)	9.2 (7.4–11.5)
	6–11	6.9 (5.2–9.0)	15.4 (12.8–18.5)	12.5 (10.1–15.3)
	12–23	8.4 (7.0–10.2)	30.3 (27.7–33.1)	16.9 (15.0–19.1)
	24–35	8.8 (7.3–10.7)	36.1 (33.0–39.3)	23.3 (20.8–26.0)
	36–59	9.0 (7.9–10.3)	29.2 (27.1–31.4)	25.2 (23.2–27.2)
Sex				
	Male	9.6 (8.6–10.8)	27.4 (25.7–29.1)	20.0 (18.4–21.7)
	Female	7.9 (6.9–9.0)	27.0 (25.1–28.9)	19.8 (18.3–21.4)
Recent Experience of Diarrhea†				
	No	8.7 (8.0–9.6)	27.3 (25.9–28.7)	19.9 (18.7–21.1)
	Yes	9.6 (6.8–13.4)	25.3 (20.3–30.9)	20.9 (16.8–25.6)
Recent Experience of Fever†				
	No	7.8 (7.0–8.8)	27.2 (25.6–28.8)	18.5 (17.2–19.9)
	Yes	10.6 (9.3–12.2)	27.2 (24.9–29.6)	22.7 (20.7–24.8)
Socioeconomic and Demographic Variables				
Division				
	Barisal	9.1 (7.0–11.7)	29.1 (25.3–33.2)	19.9 (16.7–23.4)
	Chittagong	8.1 (6.4–10.2)	29.6 (26.0–33.5)	19.6 (16.9–22.5)
	Dhaka	9.5 (7.6–11.9)	22.6 (19.3–26.1)	17.6 (14.7–20.9)
	Khulna	8.1 (6.4–10.1)	22.5 (19.2–26.2)	17.4 (14.7–20.4)
	Mymensingh	9.7 (7.9–11.9)	30.7 (27.1–34.6)	23.7 (20.9–26.6)
	Rajshahi	8.3 (6.5–10.7)	26.9 (23.6–30.4)	20.4 (16.8–24.5)
	Rangpur	7.3 (5.7–9.2)	25.7 (22.9–28.9)	17.6 (15.1–20.5)
	Sylhet	10.5 (8.9–12.3)	37.6 (33.9–41.3)	29.0 (25.9–32.3)
Place of Residence				
	Urban	9.7 (8.2–11.4)	21.7 (19.3–24.2)	18.4 (16.3–20.6)
	Rural	8.5 (7.6–9.4)	29.2 (27.5–30.9)	20.5 (19.1–22.0)
Household Wealth Status				
	Poorest	10.2 (8.8–11.9)	36.4 (33.9–39.0)	27.0 (24.5–29.6)
	Poor	8.7 (7.3–10.4)	33.3 (30.5–36.2)	22.8 (20.4–25.3)
	Well-Off	8.3 (7.2–9.4)	21.5 (19.8–23.3)	16.2 (14.9–17.7)
Drinking Water Source				
	Unimproved	11.5 (7.4–17.5)	40.0 (29.1–51.9)	27.9 (18.9–39.2)
	Improved	8.8 (8.0–9.6)	27.0 (25.6–28.5)	19.8 (18.6–21.1)
Type of Toilet				
	Unhygienic	9.5 (8.3–11.0)	34.1 (31.9–36.4)	25.6 (23.2–29.2)
	Hygienic	8.5 (7.6–9.5)	24.5 (22.9–26.2)	17.7 (16.5–19.0)
Place of Childbirth				
	Facility Birth	8.1 (6.8–9.7)	20.7 (18.9–22.6)	13.1 (11.6–14.7)
	Home Delivery	9.1 (7.9–10.6)	31.2 (29.0–33.4)	20.4 (18.5–22.3)

(*Continued*)

Table 2. (Continued)

Independent Variables		Wasting (95% CI)	Stunting (95% CI)	Underweight (95% CI)
Parental Variables				
Maternal BMI				
	Underweight (<18.50kg/m^2)	14.1 (12.1–16.5)	37.2 (34.1–40.3)	29.0 (26.1–32.1)
	Normal (18.50–24.99kg/m^2)	8.4 (7.4–9.4)	27.6 (25.9–29.4)	20.0 (18.5–21.5)
	Overweight/Obese (≥25.00kg/m^2)	6.9 (5.6–8.4)	20.7 (18.6–23.1)	14.9 (13.0–16.9)
Maternal Age (years)				
	15–24	8.7 (7.7–9.9)	26.6 (24.7–28.5)	18.4 (16.9–20.1)
	25–34	8.7 (7.7–9.9)	27.7 (25.8–29.7)	20.9 (19.2–22.6)
	35–49	9.5 (7.2–12.4)	27.9 (24.3–31.8)	23.7 (19.9–27.9)
Maternal Age at First Birth (years)				
	<18	9.3 (8.3–10.3)	29.7 (27.9–31.4)	21.9 (20.3–23.5)
	19–24	8.3–7.1–9.6)	24.7 (22.7–26.8)	17.6 (16.0–19.3)
	≥25	7.0 (4.5–10.8)	15.8 (12.1–20.3)	13.6 (10.1–17.9)
Mother's Education				
	No Education	12.3 (9.7–15.5)	40.4 (35.7–45.3)	34.5 (29.7–39.6)
	Primary	9.5 (8.2–10.9)	34.6 (32.2–37.1)	24.4 (22.1–26.7)
	Secondary	8.7 (7.6–9.9)	25.7 (23.8–27.7)	18.5 (17.1–20.1)
	Higher	6.2 (4.8–8.1)	12.1 (10.2–14.4)	9.5 (7.7–11.5)
Mother's Current Working Status				
	No	8.8 (7.8–9.9)	24.7 (23.0–26.5)	18.5 (17.1–20.0)
	Yes	8.8 (7.8–9.8)	30.9 (29.0–33.0)	22.0 (20.3–23.9)
Mother's Exposure to Television				
	No	9.0 (7.9–10.2)	33.0 (30.9–35.1)	23.7 (21.8–25.7)
	Yes	8.7 (7.7–9.7)	23.8 (22.2–25.4)	17.7 (16.4–19.1)
Mother's ANC visit Number				
	Nil	8.7 (7.7–9.9)	30.2 (28.3–32.2)	24.9 (23.1–26.8)
	1–3	9.2 (7.8–10.8)	27.7 (25.4–30.1)	17.3 (15.4–19.3)
	≥4	8.5 (7.2–10.0)	21.9 (19.9–24.0)	14.5 (12.9–16.3)
Father's Education				
	No Education	9.7 (8.1–11.6)	40.1 (37.0–43.3)	28.9 (25.8–32.2)
	Primary	8.9 (7.8–10.1)	31.6 (29.6–33.7)	22.4 (20.6–24.3)
	Secondary	9.1 (7.8–10.6)	23.7 (21.7–25.8)	17.7 (16.0–19.6)
	Higher	7.2 (5.7–9.0)	13.6 (11.5–16.0)	11.1 (9.3–13.3)
Father's Occupation				
	Agricultural	9.8 (8.4–11.5)	34.4 (31.7–37.1)	24.3 (21.7–27.1)
	Business	6.8 (5.5–8.2)	23.0 (20.5–25.7)	16.9 (14.9–19.0)
	Non-Agricultural	8.9 (7.8–10.2)	23.5 (21.8–25.3)	17.8 (16.3–19.4)
	Other	10.1 (8.1–12.5)	35.9 (32.3–39.5)	25.7 (22.7–28.9)

† Recent experience indicates sufferings from diarrhea and fever two weeks preceding the survey.

CI: Confidence interval; BMI: Body mass index; ANC: Antenatal care.

https://doi.org/10.1371/journal.pone.0256235.t002

toilet, ANC visit number, sex, and birth order children had no significant impact on wasting within different wealth statuses. Well-off families residing in Dhaka had a higher chance of having a wasted child, but other household statuses yielded insignificant results. Recent fever experience in the last two weeks was associated with poor and well-off wealth indexes, and it had higher odds of a wasted child.

Table 3. Factors associated with stunting within different wealth status.

		Poorest		Poor		Well-off	
Independent Variables		**AOR (95% CI)**	**p-value**	**AOR (95% CI)**	**p-value**	**AOR (95% CI)**	**p-value**
Child-related Variables							
Birth Order (Ref: ≥4th)							
	1st	0.93(0.68–1.29)	0.677	0.65(0.39–1.07)	0.090	0.91(0.63–1.32)	0.615
	2nd	0.87(0.64–1.19)	0.382	0.58(0.38–0.89)	0.012	0.86(0.60–1.23)	0.405
	3rd	0.92(0.66–1.29)	0.639	0.68(0.45–1.03)	0.067	0.93(0.63–1.37)	0.700
Age (months) (Ref: 0–5)							
	6–11	1.08(0.63–1.86)	0.782	0.11(0.05–0.22)	<0.001	0.10(0.01–0.81)	0.031
	12–23	2.92(0.63–1.86)	<0.001	0.38(0.22–0.67)	0.001	0.14(0.02–1.11)	0.062
	24–35	4.41(1.88–4.55)	<0.001	1.23(0.71–1.79)	0.616	0.34(0.04–2.63)	0.300
	36–59	3.11(1.90–5.09)	<0.001	1.62(1.06–2.47)	0.026	0.37(0.5–2.91)	0.348
Socioeconomic and Demographic Variables							
Division (Ref: Sylhet)							
	Barisal	0.83(0.53–1.30)	0.413	N/A	N/A	1.10(0.72–1.69)	0.652
	Chittagong	1.16(0.79–1.71)	0.445	N/A	N/A	1.04(0.74–1.45)	0.819
	Dhaka	0.77(0.51–1.18)	0.229	N/A	N/A	0.79(0.55–1.13)	0.191
	Khulna	0.41(0.26–0.71)	0.001	N/A	N/A	1.01(0.67–1.50)	0.981
	Mymensingh	0.75(0.50–1.14)	0.184	N/A	N/A	1.01(0.66–1.52)	0.997
	Rajshahi	0.58(0.37–0.89)	0.014	N/A	N/A	1.02(0.68–1.54)	0.916
	Rangpur	0.52(0.35–0.77)	0.001	N/A	N/A	1.11(0.71–1.75)	0.645
Place of residence (Ref: Rural)							
	Urban	N/A	N/A	N/A	N/A	0.94(0.76–1.16)	0.543
Drinking Water Source (Ref: Improved)							
	Unimproved	N/A	N/A	N/A	N/A	1.33(0.54–3.29)	0.540
Type of Toilet (Ref: Hygienic)							
	Unhygienic	N/A	N/A	1.06(0.84–1.33)	0.624	1.12(0.83–1.50)	0.474
Place of Childbirth (Ref: Home Delivery)							
	Facility Birth	N/A	N/A	N/A	N/A	0.89(0.72–1.11)	0.307
Parental Variables							
Maternal BMI (Ref: Overweight/Obese)							
	Underweight (<18.50kg/m^2)	1.6(1.09–2.35)	0.016	2.11(1.43–2.23)	<0.001	1.35(0.96–1.90)	0.083
	Normal (18.50–24.99kg/m^2)	1.14(0.81–1.59)	0.458	1.70(1.21–2.39)	0.002	1.02(0.81–1.29)	0.850
Maternal Age at First Birth (Ref: <18 years)							
	19–24	N/A	N/A	N/A	N/A	0.90(0.73–1.11)	0.332
	≥25	N/A	N/A	N/A	N/A	0.91(0.58–1.42)	0.662
Mother's Education (Ref: Higher)							
	No Education	1.99(0.83–4.80)	0.123	2.41(1.22–6.58)	0.016	1.70(0.96–3.02)	0.071
	Primary	1.60(0.70–3.66)	0.269	3.72(1.78–7.67)	<0.001	1.55(1.05–2.72)	0.027
	Secondary	1.66(0.73–3.78)	0.226	3.51(1.70–6.94)	0.001	1.41(1.03–1.91)	0.030
Mother's Current Working Status (Ref: Yes)							
	No	N/A	N/A	N/A	N/A	0.88(0.70–1.90)	0.241
Mother's Exposure to Television (Ref: No)							
	Yes	N/A	N/A	N/A	N/A	0.99(0.78–1.27)	0.985
Mother's ANC Visit Number (Ref: ≥4)							
	Nil	0.76(0.51–1.14)	0.296	1.16(0.74–1.84)	0.514	1.22(0.84–1.77)	0.295

(*Continued*)

Table 3. (Continued)

		Poorest		Poor		Well-off	
Independent Variables		**AOR (95% CI)**	**p-value**	**AOR (95% CI)**	**p-value**	**AOR (95% CI)**	**p-value**
	1–3	0.70(0.51–0.98)	0.028	1.23(0.89–1.72)	0.214	1.20(0.97–1.49)	0.093
Father's Education Level (Ref: Higher)							
	No Education	2.94(1.37–6.34)	0.006	1.45(0.81–2.60)	0.216	1.98(1.26–3.11)	0.003
	Primary	2.41(1.15–5.10)	0.021	1.01(0.59–1.74)	0.960	1.89(1.34–2.67)	<0.001
	Secondary	2.18(1.02–4.67)	0.045	0.87(0.50–1.50)	0.614	1.51(0.12–2.04)	0.008
Father's Occupation (Ref: Other)							
	Agricultural	N/A	N/A	N/A	N/A	0.82(0.54–1.25)	0.351
	Business	N/A	N/A	N/A	N/A	0.70(0.48–1.01)	0.055
	Non-Agricultural	N/A	N/A	N/A	N/A	0.71(0.51–1.00)	0.050

N/A stands for not applicable. Insignificant variables in Chi-square tests were not included in the adjusted model; therefore, they were replaced with N/A in the Table. p-value <0.05 is the level of significance.

AOR: Adjusted odds ratio; p-value: Probability value; CI: Confidence interval; Ref: Reference category; BMI: Body mass index; ANC: Antenatal care.

https://doi.org/10.1371/journal.pone.0256235.t003

Fig 2 exhibits the prevalence of different forms of malnutrition by place of residence and different wealth statuses. It is very clear from the figure that stunting, wasting, and underweight prevalence is higher in the poorest, followed by poor and well-off households. The prevalence of these three forms of malnutrition was also comparatively higher in Sylhet division.

Discussion

The paper aimed to identify the associated factors with childhood malnutrition and poverty in Bangladesh. In low resource countries like Bangladesh, poverty and childhood malnutrition continue to be major public health concerns. Although Bangladesh has attained excellent progress over the past few decades in different areas of health, particularly in health-related Millennium Development Goals, and has made few nutritional achievements [1, 24]. Nevertheless, the high prevalence of childhood malnutrition still exists in Bangladesh, and it cannot be denied [1]. Despite the recent economic growth and poverty reduction, the reduction rate of childhood malnutrition in Bangladesh is somewhat unsatisfactory. There is consensus that economic growth and poverty reduction alone cannot decrease malnutrition [25, 26] unless the issues of mothers' malnutrition history, teenage marriage, and inappropriate diets are addressed. According to the BDHS 2017–18 report, 31% of under-five children are still stunted and 9% are severely stunted; while 8% are wasted, with 2% being severely wasted and 22% of children are underweight, and 4% are severely underweight [13]. In Bangladesh, 21.8% of population are still living below the national poverty line [27], like many other LMICs, which is predicted to further increase due to the recent COVID-19 pandemic [28]. Besides, the ongoing pandemic is expected to increase the prevalence of childhood malnutrition [29]. Therefore, examining the associated factors with malnutrition and poverty is an enormously important topic in the current context. This is the first study in this context, using the most recent round BDHS 2017–18 dataset to the best of our knowledge.

In terms of childhood malnutrition, a clear rural-urban gap was observed in the current study. Rural children were more likely to be stunted than their urban counterparts (29.2% compared with 21.7%). Stunting was most prevalent in Sylhet (37.6%) and lowest in Dhaka and Khulna. The differences in stunting across wealth quintiles were larger (36.4%) for children whose mothers were in the lowest wealth quintile than their well-off counterparts

Table 4. Factors associated with underweight within different categories of wealth status.

		Poorest		Poor		Well-Off	
Independent Variables		**AOR (95% CI)**	**p-value**	**AOR (95% CI)**	**p-value**	**AOR (95% CI)**	**p-value**
Child-related Variables							
Birth Order (Ref: ≥4)							
	1st	1.55(0.83–2.90)	0.864	N/A	N/A	0.88(0.51–1.52)	0.634
	2nd	1.04(0.60–1.80)	0.621	N/A	N/A	0.74(0.47–1.17)	0.197
	3rd	0.97(0.57–1.63)	0.552	N/A	N/A	0.71(0.45–1.12)	0.137
Age (Ref: 0–5 months)							
	6–11	1.68(0.90–3.16)	<0.001	2.60(1.27–5.34)	0.001	0.24(0.02–2.51)	0.231
	12–23	2.95(1.71–5.08)	0.050	3.11(1.61–6.00)	0.001	0.21(0.02–2.30)	0.204
	24–35	3.50(2.05–6.00)	0.811	5.72(0.98–6.01)	0.193	0.29(0.03–3.05)	0.302
	36–59	1.68(0.90–3.16)	0.290	7.37(3.49–15.55)	0.001	0.51(0.05–5.29)	0.568
Recent Experience of Fever (Ref: No)							
	Yes	N/A	N/A	1.51(1.16–1.95)	0.002	1.30(1.03–1.64)	0.027
Socioeconomic and Demographic Variables							
Division (Ref: Sylhet)							
	Barisal	1.07(0.56–2.03)	0.995	0.53(0.28–0.99)	0.040	0.55(0.32–0.94)	0.030
	Chittagong	0.91(0.52–1.59)	0.771	0.55(0.34–0.89)	0.008	0.89(0.61–1.30)	0.538
	Dhaka	1.06(0.56–2.02)	0.523	0.62(0.38–1.01)	0.036	0.68(0.46–1.01)	0.058
	Khulna	0.82(0.37–1.82)	0.242	0.67(0.39–1.15)	0.122	0.78(0.50–1.22)	0.278
	Mymensingh	0.85(0.46–1.57)	0.864	0.85(0.52–1.40)	0.367	0.84(0.53–1.32)	0.444
	Rajshahi	0.60(0.30–1.21)	0.412	0.58(0.35–0.96)	0.037	0.74(0.46–1.17)	0.196
	Rangpur	0.79(0.45–1.41)	0.044	0.42(0.25–0.71)	0.001	0.86(0.52–1.43)	0.554
Place of Residence (Ref: Urban)							
	Rural	N/A	N/A	0.71(0.47–1.08)	0.079	N/A	N/A
Type of Toilet (Ref: Hygienic)							
	Unhygienic	1.25(0.90–1.74)	0.301	N/A	N/A	N/A	N/A
Place of Childbirth (Ref: Home Birth)							
	Facility Birth	N/A	N/A	N/A	N/A	0.89(0.68–1.11)	0.255
Parental Variables							
Maternal BMI (Ref: Overweight/Obese)							
	Underweight (<18.50kg/m^2)	2.01(1.10–3.70)	0.005	2.46(1.55–3.75)	0.000	2.09(1.41–3.09)	<0.001
	Normal (18.50–24.99kg/m^2)	0.77(0.44–1.37)	0.986	1.53(1.02–2.19)	0.030	1.39(1.05–1.85)	0.021
Maternal Age (Ref: 35–49 years)							
	15–24	1.07(0.47–2.43)	0.499	N/A	N/A	0.98(0.52–1.87)	0.958
	25–34	1.11(0.54–2.27)	0.29	N/A	N/A	1.21(0.71–2.08)	0.485
Maternal Age at First Birth (Ref: <18 years)							
	19–24	N/A	N/A	N/A	N/A	0.72(0.55–0.94)	0.014
	>25	N/A	N/A	N/A	N/A	0.85(0.47–1.52)	0.575
Mother's Education (Ref: Higher)							
	No Education	10.23(1.54–68.9)	0.008	1.48(0.65–3.34)	0.574	1.98(1.02–3.83)	0.043
	Primary	5.70(0.89–36.50)	0.077	1.15(0.57–2.34)	0.967	1.80(1.15–2.83)	0.010
	Secondary	4.96(0.78–31.50)	0.127	1.46(0.74–2.88)	0.451	1.49(1.03–2.15)	0.036
Mother's exposure to Television (Ref: No)							
	Yes	1.09(0.829–1.44)	0.529	N/A	N/A	N/A	N/A
Mother's ANC Visit Number (Ref: ≥4)							
	Nil	1.26(0.79–2.00)	0.356	0.90(0.54–1.52)	0.502	0.78(0.5–1.23)	0.285

(*Continued*)

Table 4. (Continued)

		Poorest		Poor		Well-Off	
Independent Variables		**AOR (95% CI)**	**p-value**	**AOR (95% CI)**	**p-value**	**AOR (95% CI)**	**p-value**
	1–3	0.86(0.58–1.26)	0.351	1.09(0.74–1.59)	0.945	0.96(0.75–1.24)	0.760
Father's Education (Ref: Higher)							
	No Education	2.87(0.93–8.84)	0.284	1.50(0.75–3.02)	0.215	0.94(0.55–1.62)	0.825
	Primary	1.52(0.51–4.58)	0.569	1.56(0.81–2.98)	0.149	1.45(0.98–2.13)	0.060
	Secondary	1.44(0.47–4.45)	0.760	1.29(0.67–2.48)	0.365	1.04(0.74–1.48)	0.817
Father's Occupation (Ref: Other)							
	Agricultural	N/A	N/A	0.94(0.64–1.38)	0.678	0.56(0.34–0.91)	0.019
	Business	N/A	N/A	0.73(0.47–1.23)	0.137	0.61(0.40–0.91)	0.017
	Non-Agricultural	N/A	N/A	0.79(0.54–1.14)	0.211	0.64(0.44–0.93)	0.020

N/A stands for not applicable. Insignificant variables in Chi-square tests were not included in the adjusted model; therefore, they were replaced with N/A in the Table. p-value <0.05 is the level of significance.

AOR: Adjusted odds ratio; p-value: Probability value; CI: Confidence interval; Ref: Reference category; BMI: Body mass index; ANC: Antenatal care.

https://doi.org/10.1371/journal.pone.0256235.t004

(21.5%). Children living in rural areas were more likely to be underweighted than those living in urban areas (20.5% vs. 18.4%). A similar negative association was observed between household wealth status and the proportion of underweight children, i.e., children in the poorest households were more likely to be underweight (27.0%) than children from the well-off households (16.2%). The prevalence of wasting was slightly higher among children residing in urban areas (9.7% vs. 8.8%).

The multivariate logistic regression analyses showed several predictor variables were associated with childhood malnutrition across different wealth statuses, which is in line with previous studies in Bangladesh [1–3, 18, 30] and elsewhere [4, 7, 24, 31–33]. The results demonstrate that children from the poorest and poor households were more likely to be stunted, wasted, and underweight. There remains a very close connection between poverty and childhood malnutrition, and vice-versa. Poverty often leads to financial shortages and inadequate basic amenities (such as education, health care services, food insecurity, shelter, etc.), forcing them to live impoverished lives. Worldwide, the poorest countries face the most significant burden of various types of childhood malnutrition [26]. Nutritional disparities reduce productivity and potentially decrease human capital, making countries prone to poverty and reinforcing childhood malnutrition and poverty's vicious cause-effects cycle [26].

Lack of formal parental education is strongly linked to stunting, wasting, and underweight among under-five children, supporting previous studies conducted in Bangladesh [2, 3, 18, 34] and similar settings [24, 31, 32]. The possible explanation could be that a lower level of education prevents parents from obtaining employment or leads to poorly paid employment, limiting the household incomes and reduces the purchasing capability of good quality and quantity of foods and routine medical check-ups; consequently, children suffer from various infections and parasitic diseases [35]. Furthermore, poor maternal BMI was associated with childhood malnutrition among different categories of wealth statuses, aligning the results with previous studies [1, 3, 18]. As mothers with standard BMI are likely to have healthier babies [36], maternal nutritional status needs to be included in child undernutrition policies and programs. Furthermore, stunting was significantly prevalent among children of advancing age from the poorest and poor families but insignificant for well-off households, supported by a previous study in Nigeria [37]. During the first 11 months, children are being breastfed, and nutrition

Table 5. Factors associated with wasting within different categories of wealth status.

Independent Variables		Poorest		Poor		Well-Off	
Child-related Variables		**AOR (95% CI)**	**p-value**	**AOR (95% CI)**	**p-value**	**AOR (95% CI)**	**p-value**
Birth Order (Ref: ≥4)							
	1st	1.45(0.87–2.44)	0.157	N/A	N/A	N/A	N/A
	2nd	1.23(0.74–2.05)	0.421	N/A	N/A	N/A	N/A
	3rd	1.69(1.00–2.83)	0.049	N/A	N/A	N/A	N/A
Age (Ref: 0–5 months)							
	6–11	N/A	N/A	N/A	N/A	1.14(0.82–1.59)	0.424
	12–23	N/A	N/A	N/A	N/A	0.57(0.37–0.88)	0.012
	24–35	N/A	N/A	N/A	N/A	0.65(0.48–0.89)	0.008
	36–59	N/A	N/A	N/A	N/A	0.90(0.67–1.22)	0.489
Sex (Ref: Male)							
	Female	1.50(1.08–2.07)	0.015	N/A	N/A	N/A	N/A
Recent Experience of Fever (Ref: No)							
	Yes	N/A	N/A	1.44(1.00–2.07)	0.052	1.53(1.22–1.91)	<0.001
Socioeconomic and Demographic Variables							
Division (Ref: Sylhet)							
	Barisal	N/A	N/A	0.59(0.22–1.59)	0.297	0.76(0.48–1.22)	0.258
	Chittagong	N/A	N/A	0.59(0.28–1.23)	0.161	0.85(0.60–1.22)	0.381
	Dhaka	N/A	N/A	1.09(0.55–2.15)	0.805	0.95(0.67–1.34)	0.780
	Khulna	N/A	N/A	1.46(0.72–2.98)	0.299	0.48(0.30–0.76)	0.002
	Mymensingh	N/A	N/A	1.05(0.52–2.13)	0.897	0.80(0.52–1.25)	0.333
	Rajshahi	N/A	N/A	0.91(0.45–1.85)	0.798	0.59(0.38–0.94)	0.026
	Rangpur	N/A	N/A	0.64(0.30–1.37)	0.255	0.70(0.43–1.15)	0.157
Place of Residence (Ref: Urban)							
	Rural	N/A	N/A	1.90(1.23–3.21)	0.016	N/A	N/A
Type of Toilet (Ref: Hygienic)							
	Unhygienic	N/A	N/A	1.62(1.14–2.32)	0.008	N/A	N/A
Parental Variables							
Maternal BMI (Ref: Overweight/Obese)							
	Underweight (<18.50kg/m^2)	1.47(0.86–2.54)	0.163	2.31(1.21–4.40)	0.011	2.65(1.88–3.75)	0.000
	Normal (18.50–24.99kg/m^2)	0.84(0.51–1.39)	0.504	1.33(0.74–2.39)	0.343	1.31(1.01–1.69)	0.039
Mother's Education (Ref: Higher)							
	No Education	2.78(0.71–10.86)	0.143	N/A	N/A	1.64(0.96–2.81)	0.072
	Primary	1.67(0.45–6.26)	0.445	N/A	N/A	1.22(0.86–1.73)	0.265
	Secondary	2.01(0.54–7.47)	0.299	N/A	N/A	1.27(0.95–1.69)	0.114
Mother's ANC Visit Number (Ref: ≥4)							
	Nil	N/A	N/A	1.05(0.65–1.69)	0.834	N/A	N/A
	1–3	N/A	N/A	1.14(0.70–1.88)	0.600	N/A	N/A
Father's Occupation (Ref: Other)							
	Agricultural	N/A	N/A	N/A	N/A	1.12(0.72–1.75)	0.610
	Business	N/A	N/A	N/A	N/A	0.62(0.41–0.94)	0.023
	Non-Agricultural	N/A	N/A	N/A	N/A	0.81(0.56–1.17)	0.252

N/A stands for not applicable. Insignificant variables in Chi-square tests were not included in the adjusted model; therefore, they were replaced with N/A in the Table. p-value <0.05 is the level of significance.

AOR: Adjusted odds ratio; p-value: Probability value; CI: Confidence interval; Ref: Reference category; BMI: Body mass index; ANC: Antenatal care.

https://doi.org/10.1371/journal.pone.0256235.t005

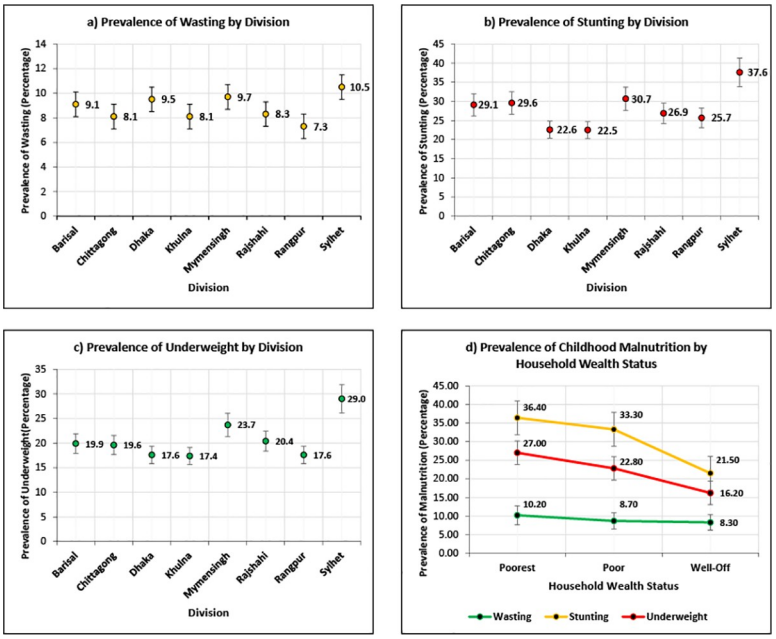

Fig 2. Prevalence of malnutrition by division and household wealth status of Bangladesh.

https://doi.org/10.1371/journal.pone.0256235.g002

from the breast milk may help them have adequate growth, but later, when they give up breast milk, the likelihood of childhood stunting increased tremendously [1].

The coexistence of poverty and malnutrition is intergenerational, and this needs to be recognized urgently by implementing effective measures to break this vicious cycle [38–40]. Prior research also showed that malnourished mothers are more likely to have malnourished children [8, 26, 41–43], and early intervention can break this cycle of poverty and childhood malnutrition. The government of Bangladesh is well conscious about this and is doing a lot in this regard. Besides, different NGOs are relentlessly working to ensure nutrition for mothers and children by implementing different programs such as Infant and Young Child Feeding, National Nutrition Programme, Suchana etc. This high prevalence of childhood malnutrition, however, questions the appropriateness of these interventions those were previously implemented.

This study has several policy implications. First, since poverty and malnutrition are intertwined, nutritional and poverty reduction strategies and initiatives should therefore be deserving of preference and should be rounded and holistic in any way. Second, the government should take robust and rigorous steps in improving nutritional status among women and their children to provide good nutritional foods for poor and underprivileged households. Third, interventions must target economic empowerment and short-term dietary supplements for people with disadvantaged economic status. Fourth, the Bangladeshi Government may wish to establish effective policies and programs in collaboration with national and international organizations, which will aid all poor women and infants during pregnancy and postnatal period. Furthermore, parents need better access to health information and education; therefore, community-based health services should be promoted at the grassroots level.

The main strengths of this study are that it used the latest nationwide DHS survey data. The surveys were carried out at the population level with a large study sample, and the results can be generalized for the whole Bangladeshi population. In addition, the appropriate statistical techniques were applied in this study for estimation. However, the limitation of this study is

the cross-sectional survey design where both exposure/predictors and outcomes were measured at the same timepoint. Therefore, no causal relationships can be inferred.

Conclusions

Our investigation has established the significant associated factors with poverty and childhood malnutrition. The study supports the need for organized efforts, especially among the poorest and poor, to reduce the degree of malnutrition. It is well-known that 12 of the 17 SDGs goals prioritize and include highly relevant indicators to nutrition, while the second-highest priority is to end poverty, hunger, food insecurity, and improved nutrition. Therefore, if we want to eradicate poverty and hunger sustainably, we need to build a systemic, healthy, and equitable society.

Acknowledgments

Authors want to thank Demographic Health Surveys (DHS) for providing and permitting us to use the datasets for independent research.

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References

1. Rahman A, Rahman S, Shakur SM, Howlader H. Risk factors of chronic childhood malnutrition: an analysis of the Bangladesh demographic and health survey 2014 data. J Public Heal From Theory to Pract 2020. https://doi.org/10.1007/s10389-020-01281-4
2. Das S, Rahman RM. Application of ordinal logistic regression analysis in determining risk factors of child malnutrition in Bangladesh. Nutr J 2011:1–11. https://doi.org/10.1186/1475-2891-10-1 PMID: 21208446
3. Rahman MS, Rahman MA, Maniruzzaman M, Howlader MH. Prevalence of undernutrition in Bangladeshi children. J Biosoc Sci 2019:1–14. https://doi.org/10.1017/S0021932019000683 PMID: 31658911
4. Uauy R, de Onis M, Grantham-McGregor S, Christian P, Katz J, Black RE, et al. Maternal and child undernutrition and overweight in low-income and middle-income countries. Lancet 2013; 382:427–51. https://doi.org/10.1016/S0140-6736(13)60937-X PMID: 23746772
5. UNICEF-WHO-World Bank Group. Malnutrition in Children—UNICEF DATA n.d. https://data.unicef.org/topic/nutrition/malnutrition/. Accessed on May 1, 2021.
6. Peña M, Bacallao J. Malnutrition and poverty. Annu Rev Nutr 2002; 22:241–53. https://doi.org/10.1146/annurev.nutr.22.120701.141104 PMID: 12055345
7. Panda BK, Mohanty SK, Nayak I, Shastri VD, Subramanian S V. Malnutrition and poverty in India: Does the use of public distribution system matter? BMC Nutr 2020; 6:1–14. https://doi.org/10.1186/s40795-019-0317-4 PMID: 32153975

8. Deolalikar AB. Poverty and child malnutrition in Bangladesh. J Dev Soc 2005; 21:55–90. https://doi.org/10.1177/0169796X05053067
9. Narayan J, John D, Ramadas N. Malnutrition in India: status and government initiatives. J Public Health Policy 2019; 40:126–41. https://doi.org/10.1057/s41271-018-0149-5 PMID: 30353132
10. International Monetary Fund. Bangladesh: Poverty Reduction Strategy Paper. vol. 12. 2012. https://doi.org/10.5089/9781475557053.002
11. Nisbett N, Davis P, Yosef S, Akhtar N. Bangladesh's story of change in nutrition: Strong improvements in basic and underlying determinants with an unfinished agenda for direct community level support. Glob Food Sec 2017; 13:21–9. https://doi.org/10.1016/j.gfs.2017.01.005
12. National Institute of Population Research and Training (NIPORT). Bangladesh Demographic and Health Survey 2014. Dhaka, Bangladesh, and Rockville, Maryland, USA: 2014.
13. National Institute of Population Research and Training (NIPORT), ICF International. Bangladesh Demographic and Health Survey 2017–18. Dhaka, Bangladesh, and Rockville, Maryland, USA: 2020. https://doi.org/10.1007/s40292-020-00419-5 PMID: 33113094
14. Perez-Escamilla R, Bermudez O, Buccini GS, Kumanyika S, Lutter CK, Monsivais P, et al. Nutrition disparities and the global burden of malnutrition. Bmj 2018;361. https://doi.org/10.1136/bmj.k2252 PMID: 29899012
15. McGovern ME, Krishna A, Aguayo VM, Subramanian S V. A review of the evidence linking child stunting to economic outcomes. Int J Epidemiol 2017; 46:1171–91. https://doi.org/10.1093/ije/dyx017 PMID: 28379434
16. Krishna A, Mejía-Guevara I, McGovern M, Aguayo VM, Subramanian S V. Trends in inequalities in child stunting in South Asia. Matern Child Nutr 2018; 14:e12517. https://doi.org/10.1111/mcn.12517 PMID: 29048726
17. Chirande L, Charwe D, Mbwana H, Victor R, Kimboka S, Issaka AI, et al. Determinants of stunting and severe stunting among under-fives in Tanzania: evidence from the 2010 cross-sectional household survey. BMC Pediatr 2015; 15:165. https://doi.org/10.1186/s12887-015-0482-9 PMID: 26489405
18. Das S, Gulshan J. Different forms of malnutrition among under five children in Bangladesh: a cross sectional study on prevalence and determinants. BMC Nutr 2017; 3:1–12. https://doi.org/10.1186/s40795-016-0122-2
19. Mistry SK, Hossain MB, Khanam F, Akter F, Parvez M, Yunus FM, et al. Individual, maternal- and household-level factors associated with stunting among children aged 0–23 months in Bangladesh. Public Health Nutr 2019; 22:85–94. https://doi.org/10.1017/S1368980018002926 PMID: 30404673
20. WHO. WHO Child Growth Standards based on length/height, weight and age. Acta Paediatr (Oslo, Norw 1992) Suppl 2006; 450:76. https://doi.org/10.1111/j.1651-2227.2006.tb02378.x PMID: 16817681
21. Rahman MA, Rahman MA, Rawal LB, Paudel M, Howlader MH, Khan B, et al. Factors influencing place of delivery: Evidence from three south-Asian countries. PLoS One 2021; 16:1–17. https://doi.org/10.1371/journal.pone.0250012 PMID: 33831127
22. Siddiquee T, Halder HR, Islam MA. Exploring the influencing factors for non-utilisation of healthcare facilities during childbirth: a special mixed-method study of Bangladesh and 13 other low- and middle-income countries based on Demographic and Health Survey data. Fam Med Community Heal 2019; 7: e000008. https://doi.org/10.1136/fmch-2018-000008 PMID: 32148722
23. World Health Organization. BMI Classification 2019 2019. http://apps.who.int/bmi/index.jsp?introPage=intro_3.html. Accessed on October 18, 2019.
24. Tariku A, Biks GA, Derso T, Wassie MM, Abebe SM. Stunting and its determinant factors among children aged 6–59 months in Ethiopia. Ital J Pediatr 2017; 43:1–9. https://doi.org/10.1186/s13052-016-0320-1 PMID: 28049500
25. Ahmad Reaz. High economic growth can't alone fight undernutrition 2016. https://www.thedailystar.net/business/high-economic-growth-cant-alone-fight-undernutrition-1311343. Accessed on January 22, 2021.
26. Siddiqui F, Salam RA, Lassi ZS, Das JK. The Intertwined Relationship Between Malnutrition and Poverty. Front Public Heal 2020; 8:1–5. https://doi.org/10.3389/fpubh.2020.00453 PMID: 32984245
27. Asian Development Bank. Poverty: Bangladesh n.d. https://www.adb.org/countries/bangladesh/poverty. Accessed on January 22, 2021.
28. The World Bank. COVID-19 to Add as Many as 150 Million Extreme Poor by 2021. Press Release 2020.
29. Fore HH, Dongyu Q, Beasley DM, Ghebreyesus TA. Child malnutrition and COVID-19: the time to act is now. Lancet 2020; 396:517–8. https://doi.org/10.1016/S0140-6736(20)31648-2 PMID: 32730742

30. Davis KA, Saltmarsh S, Chowdhury TR, Chakrabarty S, Rakib M. Socio-economic risk factors for early childhood underweight in Bangladesh. Global Health 2018; 14:1–12. https://doi.org/10.1186/s12992-017-0319-4 PMID: 29310698

31. Khan GN, Turab A, Khan MI, Rizvi A, Shaheen F, Ullah A, et al. Prevalence and associated factors of malnutrition among children under-five years in Sindh, Pakistan: a cross-sectional study. BMC Nutr 2016; 2:1–7. https://doi.org/10.1186/s40795-016-0112-4

32. Mukabutera A, Thomson DR, Hedt-gauthier BL, Basinga P, Nyirazinyoye L, Murray M. Risk factors associated with underweight status in children under five: an analysis of the 2010 Rwanda Demographic Health Survey (RDHS). BMC Nutr 2016:1–12. https://doi.org/10.1186/s40795-016-0078-2

33. Tosheno D, Mehretie Adinew Y, Thangavel T, Bitew Workie S. Risk Factors of Underweight in Children Aged 6–59 Months in Ethiopia. J Nutr Metab 2017;2017. https://doi.org/10.1155/2017/6368746 PMID: 29259827

34. Star TD. Child Nutrition: Multisectoral Approach For Investing In The Future 2015. https://www.thedailystar.net/child-nutrition-multisectoral-approach-for-investing-in-the-future-7925. Accessed on January 22, 2021.

35. Rahman M, Rahman S, Aziz M, Id R. Prevalence of and factors associated with anaemia in women of reproductive age in Bangladesh, Maldives and Nepal: Evidence from nationally-representative survey data 2021:1–20. https://doi.org/10.1371/journal.pone.0245335

36. Torlesse H, Aguayo VM. Aiming higher for maternal and child nutrition in South Asia. Matern Child Nutr 2018; 14:e12739. https://doi.org/10.1111/mcn.12739 PMID: 30499249

37. Akombi BJ, Agho KE, Hall JJ, Merom D, Astell-Burt T, Renzaho AMN. Stunting and severe stunting among children under-5 years in Nigeria: A multilevel analysis. BMC Pediatr 2017; 17:1–16. https://doi.org/10.1186/s12887-016-0759-7 PMID: 28056921

38. Arlinghaus KR, Truong C, Johnston CA, Hernandez DC. An intergenerational approach to break the cycle of malnutrition. Curr Nutr Rep 2018; 7:259–67. https://doi.org/10.1007/s13668-018-0251-0 PMID: 30324333

39. Cheng TL, Johnson SB, Goodman E. Breaking the intergenerational cycle of disadvantage: the three generation approach. Pediatrics 2016; 137. https://doi.org/10.1542/peds.2015-2467 PMID: 27244844

40. Bird K. The intergenerational transmission of poverty: An overview. Chronic Poverty 2013:60–84.

41. Setboonsarng Sununtar. Child Malnutrition as a Poverty Indicator:An Evaluation in the Context of Different Development Interventions in Indonesia. Matern Child Nutr 2005; 15:1–9.

42. Rahman M, Halder HR, Siddiquee T, Farjana SA, Roshid HO, Khan B, et al. Prevalence and determinants of double burden of malnutrition in Bangladesh: evidence from a nationwide cross-sectional survey. Nutrire. 2021 Dec; 46(2):1–2. https://doi.org/10.1186/s41110-021-00140-w

43. Khan MS, Halder HR, Rashid M, Afroja S, Islam M. Impact of socioeconomic and demographic factors for underweight and overweight children in Bangladesh: A polytomous logistic regression model. Clinical Epidemiology and Global Health. 2020 Dec 1; 8(4):1348–55. https://doi.org/10.1016/j.cegh.2020.05.010