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RESEARCH ARTICLE

Prevalence of undernutrition in Bangladeshi children

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Abstract

Child undernutrition is a major public health problem throughout the world, particularly in developing countries. The main objective of this study was to identify the risk factors for acute undernutrition among under-5 children in Bangladesh. Data were taken from the nationally representative Bangladesh Demographic Health and Survey conducted in 2014. The study sample comprised 7131 under-5 children. Of these, 4.6% were found to be severely wasted (Z-score <-3.0), 11.1% moderately wasted ($-3.0 \leq Z$-score < -2.0) and 84.3% adequately nourished (Z-score ≥ -2.0). Chi-squared analysis was used to investigate the association between child nutrition status and selected covariates. Multinomial logistic regression was applied to identify the risk factors for acute undernutrition. The selected factors division, place of residence, sex of child, place of delivery, child age, respiratory illness, size at birth, measles vaccination, fever, diarrhoea, maternal BMI, maternal education, paternal occupation, wealth index and household toilet facilities were found to be highly significant ($p < 0.05$) in the analysis. Multinomial regression analysis revealed that residence in Barisal and Chittagong divisions, a smaller than average size at birth and low maternal BMI (≤ 18.50 kg/m^2) were significant determinants of both moderate and severe acute undernutrition among under-5 children in Bangladesh.

Keywords: Acute undernutrition; Weight-for-age; Wasting

Introduction

Child undernutrition is a major public health problem in developing countries, including Bangladesh (Alom *et al.*, 2012; Hasan *et al.*, 2016). Almost 45% of the 10–11 million under-5 children who die each year die from undernutrition (Pelletier & Frongillo, 2003; Collins *et al.*, 2006; Das & Rahman, 2011; Meshram *et al.*, 2012; Black *et al.*, 2013; Demissie & Worku, 2013; Rahman, 2015; Pravana *et al.*, 2017). Consequently, undernutrition is considered the paramount leading cause of morbidity and mortality among under-5 children (Groenewold & Tilahun, 1990; Rajaram *et al.*, 2003; Rahman & Chowdhury, 2007; Amsalu & Tigabu, 2008; Das & Rahman, 2011; Meshram *et al.*, 2012; Pravana *et al.*, 2017). Its consequences are severe and wide-ranging, including an enduring negative impact on children's physical and mental growth (Rahman *et al.*, 2009; Das & Rahman, 2011; Black *et al.*, 2013) and the poor development of children's social skills (Pelletier & Frongillo, 2003; Rahman *et al.*, 2009). In addition, it has been found to be correlated with poor academic performance (Khanam *et al.*, 2011; Black *et al.*, 2013) and lower survival capacity during childhood (Pasricha & Biggs, 2010). Childhood undernutrition is also responsible for various chronic diseases and low productivity in adulthood (Pelletier & Frongillo, 2003; Rahman *et al.*, 2009).

Three anthropometric parameters are widely used to determine child nutritional status: height-for-age (stunting), weight-for-height (wasting) and weight-for-age (underweight) (Shetty, 2003;

Akombi *et al.*, 2017). Black *et al.* (2008) reported that of these, stunting and wasting are still global health concerns. Stunting is caused by chronic undernutrition, which encumbers the linear growth of the child, whereas acute undernutrition is the key cause of wasting, which is associated with recent weight loss or failure to gain weight (WHO, 2006). As a significant indicator of acute undernutrition, wasting is considered a better predictor of mortality among children during the first five years of life (WHO, 2006; Black *et al.*, 2008, 2013). For instance, children with severe acute undernutrition have been found to be almost nine times more likely to die than nourished children (UNICEF, 2009). In 1990, an estimated 58 million under-5 children were wasted, but in 2011 this number declined to 52 million (an 11% decrease) (de Onis *et al.*, 2015). Although 8% of under-5 children were wasted globally in 2011, the average rate of wasting remained high in south–central Asia (15%) (de Onis *et al.*, 2015). Black *et al.* (2013) revealed that wasting accounts for 12.6% of total child deaths.

In 2017, globally almost 51 million under-5 children were wasted, and nearly 53% of these (27 million) were living in South Asia (UNICEF *et al.*, 2018). Previous studies have established that maternal education (Phengxay *et al.*, 2007; Meshram *et al.*, 2012; Demissie & Worku, 2013; Mishra *et al.*, 2014; Olita'a *et al.*, 2014; Rabbi & Karmaker, 2015; Ambadekar & Zodpey, 2017), paternal education (Meshram *et al.*, 2012; Olita'a *et al.*, 2014; Musa *et al.*, 2017; Pravana *et al.*, 2017), urban/rural place of residence (Rabbi & Karmaker, 2015; Rahman, 2015), sex (Meshram *et al.*, 2012; Demissie & Worku, 2013; Rabbi & Karmaker, 2015; Akombi *et al.*, 2017; Khan *et al.*, 2017), age (Rahman *et al.*, 2009; Alom *et al.*, 2009; Meshram *et al.*, 2012; Fuchs *et al.*, 2014; Aheto *et al.*, 2015; Habyarimana, 2016; Akombi *et al.*, 2017; Das & Gulshan, 2017; Khan *et al.*, 2017), measles vaccination (Rahman *et al.*, 2009; Black *et al.*, 2013; Ambadekar & Zodpey, 2017), fever (Rahman *et al.*, 2009; Dabale & Sharma, 2014; Ayana *et al.*, 2015; Habyarimana, 2016; Akombi *et al.*, 2017), maternal BMI (Rayhan & Khan, 2006; Rahman *et al.*, 2009; Demissie & Worku, 2013; Fuchs *et al.*, 2014; Rahman, 2015; Chowdhury *et al.*, 2016; Habyarimana, 2016; Akombi *et al.*, 2017; Das & Gulshan, 2017), birth weight (Rayhan & Khan, 2006; Rahman *et al.*, 2009; Demissie & Worku, 2013; Rahman, 2015; Aheto *et al.*, 2015; Akombi *et al.*, 2017), maternal age (Rabbi & Karmaker, 2015; Rahman, 2015), mass media exposure (Rabbi & Karmaker, 2015; Rahman, 2015) and household wealth status (Meshram *et al.*, 2012; Rabbi & Karmaker, 2015; Fuchs *et al.*, 2014; Habyarimana, 2016; Ambadekar & Zodpey, 2017; Pravana *et al.*, 2017; Khan *et al.*, 2017) are significantly associated with acute undernutrition among under-5 children.

Despite commendable progress in reducing child and maternal mortality in accordance with the Millennium Development Goals (MDGs), child wasting remains a persistent problem in Bangladesh (Mohsena *et al.*, 2017). Recently, the World Bank found that Bangladesh has outperformed its neighbouring countries in Human Capital Index improvements and productivity. However, Bangladeshi children are endangered as a consequence of inadequate nutrition and lack of proper facilities (Musa *et al.*, 2017; Munirul Islam *et al.*, 2019). Inadequate maternal and child nutrition is a prime public health problem in Bangladesh, and the reduction of child undernutrition through appropriate initiatives would be an important step towards reducing childhood morbidity and mortality in the country (Chowdhury *et al.*, 2011). This present study was undertaken to determine the factors relating to wasting of children in Bangladesh.

Methods

Data sources

The datasets used in the study were derived from Bangladesh Demographic and Health Survey (BDHS) 2014. This was a cross-sectional study, conducted by the National Institute of Population Research and Training (NIPORT) of the Ministry of Health and Family Welfare of Bangladesh using a two-stage stratified sampling method (NIPORT *et al.*, 2016). From the expected 18,000

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households, 1,7863 ever-married women aged 15–49 were interviewed with a response rate of 98%. A total of 7886 under-5 children's information was available in the BDHS 2014 dataset. Among the 7886 children, 755 subjects were excluded due to a huge number of missing cases and finally 7131 children were included in this study. The children's information was collected from their mother.

Outcome variables

The outcome variable was wasting, measured by the weight-for-height (WHZ) *Z*-score, which is widely used to measure acute undernutrition. This was classified into three categories: adequately nourished (Z-score≥ -2.0), moderately wasted ($-3.0 \leq Z$-score< -2.0) and severely wasted (Z-score < -3.0). The *Z*-scores were calculated from the ages, heights and weights of the children using WHO AnthroPlus Software version 3.2.2, 2011 (WHO, 2010).

Predictor variables

Based on an extensive literature review on acute undernutrition (Rahman *et al.*, 2009; Rabbi & Karmaker, 2015; Rahman, 2015; Aheto *et al.*, 2015; Habyarimana, 2016; Akombi *et al.*, 2017; Pravana *et al.*, 2017; Das & Gulshan, 2017; van Cooten *et al.*, 2019), the considered covariates were: geographical division (Barisal, Chittagong, Dhaka, Khulna, Rajshahi, Rangpur and Sylhet); place of residence (urban, rural); sex (male, female); place of delivery (respondent's home, other); child age (<1 year, ≥1 year); respiratory illness (no, yes); size at birth (<average, ≥average); measles vaccination (no, yes); fever within 2 weeks of survey (no, yes); diarrhoea within 2 weeks of survey (no, yes); maternal age at first birth (<20 years, ≥20 years); maternal BMI (≤18.50, 18.51–25.00 and >25.00 kg/m^2); maternal and paternal education (none, primary, secondary and higher), maternal occupation (housewife, agricultural sector, non-agricultural sector and service sector); paternal occupation (agricultural sector, non-agricultural sector, business and service sector); wealth index (poor, middle, rich); source of drinking water (open source, piped and tube well); toilet facilities (no facilities, hanging toilet, pit toilet, flush toilet); number of under-5 children (1, 2, ≥3); and birth order (first birth, second, third or above).

Statistical analysis

Descriptive statistics were calculated to determine the frequency and percentage of the selected characteristics. Pearson's Chi-squared test was applied to determine the relationship between acute undernutrition and the selected predictor risk factors. Multinomial multiple logistic regression analysis was conducted to identify the high risk factors for acute undernutrition. Significance was based on $p < 0.05$ and odds ratios (OR) and 95% confidence intervals (CIs). SPSS version 23.00 was used for the analysis.

Results

A total of 7131 under-5 children were selected to determine the risk factors associated with acute undernutrition. Table 1 shows the background characteristics of the under-5 children and the prevalence of moderate and severe wasting due to acute undernutrition. More than two-thirds (68.4%) of the children were from rural areas. More than a third (36.6%) were delivered at home and most (98.9%) were a single birth. Around one-fifth were less than 1 year old. Most of children were average or above-average size at birth. More than a quarter of the children had not received a measles vaccination. Almost 37% had suffered from recent fever and a few (5%) had suffered from diarrhoea. About 15% had respiratory problems at the time of the survey. A large percentage (73%) were born to mothers who had given birth to their first child before the age of 20 years. More than a quarter of mothers had a BMI of ≤18.5. Moreover, almost 15% of mothers and a

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Table 1. Prevalence of moderate and severe wasting among under-5 children by background characteristics, Bangladesh, 2014

Characteristic	Overall *N* (%)	Moderately wasted *n* (%)	Severely wasted *n* (%)	Adequately nourished *n* (%)	*p*-value[a]
Division					
Barisal	838 (11.8)	107 (12.8)	57 (6.8)	674 (80.4)	0.002
Chittagong	1356 (19.0)	151 (11.1)	66 (4.9)	1139 (84.0)	
Dhaka	1245 (17.5)	121 (9.7)	45 (3.6)	1079 (86.7)	
Khulna	792 (11.1)	78 (9.8)	38 (4.8)	676 (85.4)	
Rajshahi	887 (12.4)	120 (13.5)	39 (4.4)	728 (82.1)	
Rangpur	880 (12.3)	105 (11.9)	41 (4.7)	734 (83.4)	
Sylhet	1133 (15.9)	108 (9.5)	42 (3.7)	983 (86.8)	
Place of residence					
Urban	2250 (31.6)	196 (8.7)	109 (4.8)	1945 (86.4)	<0.001
Rural	4881 (68.4)	594 (12.2)	219 (4.5)	4068 (83.3)	
Sex of child					
Male	3664 (51.4)	413 (11.3)	197 (5.4)	3054 (83.4)	0.004
Female	3467 (48.6)	377 (10.9)	131 (3.8)	2959 (85.3)	
Place of delivery					
At home	2612 (36.6)	306 (11.7)	145 (5.6)	2161 (82.7)	0.004
Not at home	4519 (63.4)	484 (10.7)	183 (4.0)	3852 (85.2)	
Birth status					
Single birth	7049 (98.9)	782 (11.1)	323 (4.6)	5944 (84.3)	0.760
Multiple birth	82 (1.1)	8 (9.8)	5 (6.1)	69 (84.1)	
Child's age (years)					
<1	1401 (19.6)	169 (12.1)	105 (7.5)	1127 (80.4)	<0.001
≥1	5730 (80.4)	621 (10.8)	223 (3.9)	4886 (85.3)	
Respiratory illness					
No	6113 (85.7)	644 (10.5)	279 (4.6)	5190 (84.9)	0.001
Yes	1018 (14.3)	146 (14.3)	49 (4.8)	823 (80.8)	
Size at birth					
<Average	826 (11.6)	131 (15.9)	62 (7.5)	633 (76.6)	<0.001
≥Average	6305 (88.4)	659 (10.5)	266 (4.2)	5380 (85.3)	
Measles vaccination					
No	1891 (26.5)	216 (11.4)	135 (7.1)	1540 (81.4)	<0.001
Yes	5240 (73.5)	574 (11.0)	193 (3.7)	4473 (85.4)	
Fever					
No	4494 (63.0)	454 (10.1)	197 (4.4)	3843 (85.5)	0.001
Yes	2637 (37.0)	336 (12.7)	131 (5.0)	2170 (82.3)	

(*Continued*)

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Table 1. (*Continued*)

Characteristic	Overall *N* (%)	Moderately wasted *n* (%)	Severely wasted *n* (%)	Adequately nourished *n* (%)	*p*-value[a]
Diarrhoea					
No	6778 (95.0)	740 (10.9)	306 (4.5)	5732 (84.6)	0.042
Yes	353 (5.0)	50 (14.2)	22 (6.2)	281 (79.6)	
Maternal age at first birth (years)					
<20	5206 (73.0)	596 (11.4)	596 (11.4)	4363 (83.8)	0.145
≥20	1925 (27.0)	194 (10.1)	81 (4.2)	1650 (85.7)	
Maternal BMI (kg/m^2)					
≤18.50	1612 (22.6)	244 (15.1)	97 (6.0)	1271 (78.8)	<0.001
18.51–25.00	4149 (58.2)	454 (10.9)	178 (4.3)	3517 (84.8)	
>25.00	1370 (19.2)	92 (6.7)	53 (3.9)	1225 (89.4)	
Maternal education					
No education	1099 (15.4)	132 (12.0)	44 (4.0)	923 (84.0)	0.007
Primary	1984 (27.8)	237 (11.9)	115 (5.8)	1632 (82.3)	
Secondary	3293 (45.2)	355 (10.8)	132 (4.0)	2806 (85.2)	
Higher	755 (10.6)	66 (8.7)	37 (4.9)	652 (86.4)	
Paternal education					
No education	1773 (24.9)	214 (12.1)	79 (4.5)	1480 (83.5)	0.118
Primary	2152 (30.2)	249 (11.6)	116 (5.4)	1787 (83.0)	
Secondary	2170 (30.4)	221 (10.2)	93 (4.3)	1856 (85.5)	
Higher	1036 (14.5)	106 (10.3)	40 (3.9)	888 (85.9)	
Maternal occupation					
Housewife	5336 (74.8)	569 (10.7)	249 (4.7)	4526 (84.6)	0.090
Agriculture	866 (12.1)	123 (14.2)	34 (3.9)	709 (81.9)	
Non-agriculture	651 (9.1)	71 (10.9)	30 (4.6)	550 (84.5)	
Service sector	278 (3.9)	27 (9.7)	15 (5.4)	278 (3.9)	
Paternal occupation					
Agriculture	1751 (24.6)	220 (12.6)	84 (4.8)	1447 (82.6)	0.017
Non-agriculture	1435 (20.1)	179 (12.5)	71 (4.9)	1185 (82.6)	
Business	1814 (25.4)	190 (10.5)	74 (4.1)	1550 (85.4)	
Service sector	2131 (29.9)	201 (9.4)	99 (4.6)	1831 (85.9)	
Wealth index					
Poor	2899 (40.7)	385 (13.3)	163 (5.6)	2351 (81.1)	0.001
Middle	1402 (19.7)	154 (11.0)	55 (3.9)	1193 (85.1)	
Rich	2830 (39.6)	251 (8.9)	110 (3.9)	2469 (87.2)	

(*Continued*)

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Table 1. (*Continued*)

Characteristic	Overall *N* (%)	Moderately wasted *n* (%)	Severely wasted *n* (%)	Adequately nourished *n* (%)	*p*-value[a]
Source of drinking water					
Open source	806 (11.3)	96 (11.9)	46 (5.7)	664 (82.4)	0.296
Piped	532 (7.5)	50 (9.4)	23 (4.3)	459 (86.3)	
Tube well	5793 (81.2)	644 (11.1)	259 (4.5)	4890 (84.4)	
Toilet facility					
No facility	178 (2.5)	33 (18.3)	11 (6.2)	134 (75.3)	0.002
Hanging toilet	226 (3.2)	30 (13.3)	8 (3.5)	188 (83.2)	
Pit toilet	5553 (77.9)	623 (11.2)	263 (4.7)	4667 (84.0)	
Flush toilet	1174 (16.5)	104 (8.9)	46 (3.9)	1024 (87.2)	
No. under-5 children					
1	4809 (67.5)	552 (11.5)	215 (4.5)	4052 (84.1)	0.358
2	1907 (26.7)	195 (10.2)	88 (4.6)	1624 (85.2)	
≥3	415 (5.8)	43 (10.4)	25 (6.0)	347 (83.6)	
Birth order					
1st	2758 (38.7)	307 (11.1)	119 (4.3)	2332 (84.6)	0.960
2nd	2144 (30.1)	229 (10.7)	101 (4.7)	1814 (84.6)	
3rd	1128 (15.8)	127 (11.3)	54 (4.8)	947 (84.0)	
≥4th	1101 (15.4)	127 (11.5)	54 (4.9)	920 (83.6)	

[a]*p*-value obtained from Chi-squared test.

quarter of fathers had never received any kind of formal education. Most of the mothers defined their work status as housewife, while a majority of the fathers were working in the service sector. More than 40% of households were categorized as poor. More than 60% of respondents were not exposed to television. Furthermore, most of the respondent households used a tube-well for their drinking water and more than 77% of families had pit toilets.

Table 1 shows the prevalence of moderate and severe wasting by the selected characteristics of the under-5 children. It also shows that 11.1% of Bangladeshi children were moderately wasted and 4.6% were severely wasted in 2014. Overall, 15.7% were suffering from acute undernutrition. Apart from birth status, maternal age at first birth, paternal education and source of drinking water, all other covariates were significantly associated with wasting in under-5 children. The percentage of children with moderate wasting was the highest in Rajshahi (13.5%) whereas the rate of severe wasting was highest in Barisal division (6.2%). Moderate wasting was significantly higher in rural areas (12.2%) compared with urban areas (8.7%), but severe wasting was lower in rural than in urban children. Boys were more susceptible to both moderate and severe wasting (11.3% and 5.4% respectively) than girls (10.9% and 3.8% respectively). Children who were delivered at home had a higher likelihood of being moderately or severely wasted (11.7% and 5.6% respectively) compared with those who were not born at home. The prevalence of moderate and severe wasting was the highest among children aged below 1 year (12.1% and 7.5%, respectively).

Children who were smaller than average at birth had a higher likelihood of being moderately or severely wasted than other children. Both moderate and severe wasting rates were higher in

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children suffering from respiratory problems than their counterparts who were not. Fever was also shown to be related to higher moderate and severe wasting (12.7% and 5.0% respectively). Additionally, the prevalence of moderate and severe wasting was the highest (14.2% and 6.2%, respectively) among children suffering from diarrhoea. Compared with children who were not vaccinated for measles, vaccinated children had a lower percentage of both moderate and severe wasting. Children whose mothers had a low BMI (≤18.50) had the highest percentages of moderate and severe wasting (15.1% and 6.0% respectively) compared with those whose mothers had a BMI greater than 25.00 (6.7% and 3.9%, respectively). Children in poor families had a higher percentage of moderate and severe wasting than those in rich or middle-income families. The prevalence of moderate wasting decreased with an increase in maternal education. Also, the rate of severe wasting was higher in children whose fathers and mothers worked in the agricultural sector. Moderate and severe wasting were the highest (18.3% and 6.2% respectively) for children whose families did not have proper toilet facilities.

A multinomial multiple logistic regression analysis was performed to identify the high risk factors for acute undernutrition (Table 2). The children of Barisal, Chittagong, Rajshahi and Rangpur divisions had 1.57, 1.38, 1.64 and 1.33, respectively, times greater odds of being moderately wasted compared with children of Sylhet division. Also, the odds of being severely wasted were 2.11, 1.62 and 1.52 times higher among children in Barisal, Chittagong and Khulna divisions, respectively, than among those in Sylhet division. Furthermore, children from rural areas had 1.23 times greater odds of being moderately wasted than their urban counterparts. Boys possessed 1.48 times greater odds of becoming severely wasted than girls.

Children who were smaller than average at birth were respectively 1.65 and 1.74 times more likely to be moderately and severely wasted compared with those who were average or larger than average at birth. Moreover, children who did not receive measles vaccinations were 1.58 times more likely to be severely wasted than their counterparts who did. In addition, children free of fever were almost 15% less likely to be moderately wasted than children who had a fever. The children of mothers with BMI ≤ 18.50 were 2.22 and 1.45 times more likely to be moderately and severely wasted than the children whose mothers have a BMI >25.00. The children of mothers with BMIs of 18.51–25.00 had a 1.58 times higher risk of becoming moderately wasted compared with those whose mothers with a BMI > 25.00 kg/m^2. Also, the children of poor families were 1.51 times more vulnerable to being severely wasted than those of rich families (Table 2).

Discussion

The pattern of change in prevalence of overall wasting among under-5 children in Bangladesh over the period 2000 to 2014, using BDHS data, is shown in Figure 1. The percentage of acutely undernourished under-5 children increased from 10.0% in 2000 to 17.0% in 2007, and thereafter remained relatively constant at around 15–16%. This is a troubling indication of Bangladesh's public health status, particularly for under-5 children.

The present study was undertaken to investigate the determinants of undernutrition among under-5 children in Bangladesh using public domain survey data. The data used (BDHS-2014) pertained to both individuals and households. They therefore contain information on individual risk factors and those that stem from shared exposures. The explanatory variables found to be significantly associated with acute undernutrition were geographic division, urban/rural place of residence, sex of the child, place of delivery, child's age, respiratory illness, size at birth, measles vaccination, fever, diarrhoea, maternal BMI, maternal education, paternal occupation, paternal occupation, wealth index of household and household toilet facilities. In the multivariate analysis, variables showing a significant association with moderate wasting were geographic division, urban/rural place of residence, size at birth, fever and maternal BMI, while those correlated with severe wasting were geographic division, sex of the child, size at birth, measles vaccination, maternal BMI and wealth index. The study also found that, overall, 15.7% of under-5 children in

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Table 2. Multinomial logistic regression analysis of moderate and severe wasting among under-5 children in Bangladesh, 2014

Characteristic	Moderate wasting		Severe wasting	
	OR [95% CI]	*p*-value	OR [95% CI]	*p*-value
Division				
Barisal	1.57 [1.16–2.11]	0.003	2.11 [1.37–3.24]	0.001
Chittagong	1.38 [1.05–1.81]	0.018	1.62 [1.07–2.44]	0.021
Dhaka	1.17 [0.88–1.55]	0.278	1.12 [0.72–1.75]	0.618
Khulna	1.22 [0.88–1.68]	0.230	1.52 [0.95–2.43]	0.082
Rajshahi	1.64 [1.22–2.19]	0.001	1.45 [0.91–2.32]	0.117
Rangpur	1.33 [0.98–1.79]	0.064	1.43 [0.90–2.27]	0.128
Sylhet (Ref.)				
Place of residence				
Rural	1.23 [1.01–1.50]	0.035	0.82 [0.62–1.09]	0.170
Urban (Ref.)				
Sex of children				
Male	1.06 [0.91–1.23]	0.448	1.48 [1.18–1.86]	0.001
Female (Ref.)				
Place of delivery				
At home	0.85 [0.71–1.00]	0.056	1.04 [0.81–1.33]	0.764
Not at home (Ref.)				
Child's age (year)				
<1	1.20 [0.93–1.54]	0.156	1.31 [0.93–1.85]	0.119
≥1 (Ref.)				
Respiratory illness				
No	0.84 [0.67–1.04]	0.100	1.08 [0.77–1.53]	0.628
Yes (Ref.)				
Size at birth				
<Average	1.65 [1.32–2.05]	<0.001	1.74 [1.28–2.36]	<0.001
≥Average (Ref.)				
Measles vaccination				
No	0.93 [0.74–1.18]	0.555	1.58 [1.14–2.17]	0.005
Yes (Ref.)				
Fever				
No	0.85 [0.72–1.01]	0.073	0.88 [0.68–1.13]	0.332
Yes (Ref.)				
Diarrhoea				
No	0.80 [0.58–1.10]	0.175	0.83 [0.52–1.32]	0.429
Yes (Ref.)				

(*Continued*)

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Table 2. (*Continued*)

Characteristic	Moderate wasting		Severe wasting	
	OR [95% CI]	*p*-value	OR [95% CI]	*p*-value
Maternal BMI (kg/m^2)				
≤18.50	2.22 [1.70–2.91]***	<0.001	1.45 [1.00–2.11]	0.048
18.51–25.00	1.58 [1.24–2.02]***	<0.001	1.05 [0.76–1.46]	0.758
>25.00 (Ref.)				
Maternal education				
No education	1.02 [0.71–1.45]	0.912	0.70 [0.42–1.18]	0.184
Primary	1.06 [0.77–1.47]	0.693	1.06 [0.67–1.65]	0.810
Secondary	1.04 [0.77–1.40]	0.791	0.80 [0.53–1.21]	0.300
Higher (Ref.)				
Maternal occupation				
Housewife	0.99 [0.65–1.52]	0.978	0.81 [0.46–1.43]	0.476
Agriculture	1.21 [0.76–1.93]	0.419	0.72 [0.36–1.40]	0.337
Non-agriculture	0.99 [0.61–1.62]	0.979	0.86 [0.44–1.67]	0.655
Service sector (Ref.)				
Paternal occupation				
Agriculture	1.08 [0.86–1.36]	0.475	0.97 [0.69–1.36]	0.873
Non-agriculture	1.18 [0.94–1.48]	0.149	0.96 [0.68–1.34]	0.819
Business	1.11 [0.89–1.37]	0.342	0.93 [0.68–1.28]	0.681
Service sector (Ref.)				
Wealth index				
Poor	1.20 [0.95–1.51]	0.128	1.51 [1.06–2.14]	0.019
Middle	1.05 [0.83–1.34]	0.681	1.03 [0.71–1.50]	0.875
Rich (Ref.)				
Toilet facility				
No facility	1.33 [0.82–2.15]	0.247	1.17 [0.55–2.50]	0.682
Hanging toilet	0.88 [0.54–1.43]	0.623	0.60 [0.26–1.38]	0.234
Pit toilet	0.87 [0.67–1.12]	0.294	0.95 [0.65–1.40]	0.820
Flush toilet (Ref.)				

The analysis reference category was 'nourished'.
Ref.: reference category; OR: Odds Ratio; CI: Confidence Interval.

Bangladesh suffered from acute undernutrition in 2014. This proportion is very high compared with the global wasting rate of 8.0% (de Onis *et al.*, 2015). Thus, acute child undernutrition is a serious problem for public health in Bangladesh.

The study explored some divisional differences in the nutritional status of children. Children living in Barisal and Chittagong divisions were found to be at higher risk of moderate and severe wasting than those living in Sylhet. Bangladesh region has been shown to be a significant determinant of wasting in previous studies (Chowdhury *et al.*, 2016; Akombi *et al.*, 2017; Das & Gulshan, 2017). Furthermore, this study found that rural children had a higher risk of being

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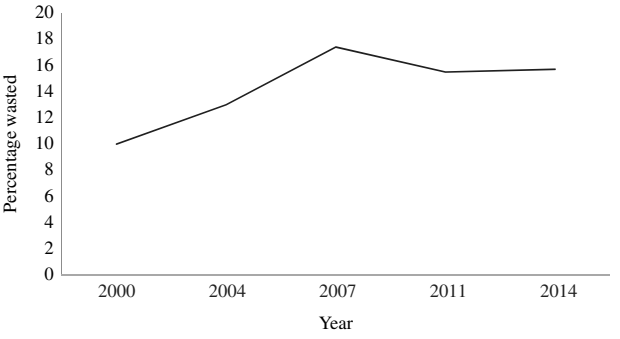

Figure 1. Trends in overall prevalence of acutely malnourished children in Bangladesh, 2000–2014.

wasted than those from urban areas, probably due to lower access to adequate education, poorer household socioeconomic circumstances, poorer quality medical facilities, lack of transportation and individuals' poor knowledge about nutrition. This finding corroborates those of previous studies (Rabbi & Karmaker, 2015; Rahman, 2015; Akombi *et al.*, 2017; Rahman & Rahman, 2019). The study also found that sex of the child was an important indicator of wasting, with male children being at 1.48 times higher risk of suffering from severe acute undernutrition than female children. This finding is consistent with previous studies conducted in Bangladesh (Rabbi & Karmaker, 2015), Ethopia (Demissie & Worku, 2013), Nigeria (Akombi *et al.*, 2017) and India (Meshram *et al.*, 2012). Although traditionally male children received more attention from parents in Bangladesh, this situation has been changing recently. The Government of Bangladesh has implemented policies and programmes aimed at enhancing female education, with the provision of stipends and free education for female students and has encouraged female participation in every job sector. This has resulted in an upgrade of the economic conditions of women in Bangladesh, which has helped them participate in decision-making in almost all sectors where they are involved, especially within their own families. Consequently, parents now value the intelligence of their female children. Therefore, female children no longer face discrimination in attention, adequate food provision, care and support.

Child's size at birth was a significant indicator of acute undernutrition. The results of this study suggest that children who were perceived to be of smaller than average size at birth had a higher risk of being wasted, which fits with the findings of previous research in Bangladesh (Rayhan & Khan, 2006; Rahman *et al.*, 2009; Rahman, 2015), Nigeria (Akombi *et al.*, 2017), Ethiopia (Demissie & Worku, 2013) and Ghana (Aheto *et al.*, 2015). Since lower birth size is a salient predictor of wasting, reducing the factors influencing this, such as poor maternal nutritional and inadequate prenatal care, might lead to a reduction in the prevalence of wasting (Black *et al.*, 2013). In addition, acute undernutrition was more prevalent in the children who suffered from fever, which is also a result consistent with those of previous studies (Rahman *et al.*, 2009; Dabale & Sharma, 2014, Ayana *et al.*, 2015; Habyarimana, 2016; Akombi *et al.*, 2017). Ayana *et al.* (2015) demonstrated that febrile illness is positively correlated with reduced food intake and increased loss of fluids, which might lead to acute childhood undernutrition.

Black *et al.* (2013) pointed out that children suffering from measles were more vulnerable to acute undernutrition and death. This study also found an increased risk of wasting among children who did not receive a measles vaccination, confirming previous research (Rahman *et al.*, 2009; Black *et al.*, 2013; Ambadekar & Zodpey, 2017). As measles is preventable with vaccination, the result implies that in addition to offering protection from the disease, measles vaccination can substantially reduce the proportion of wasted children.

A mother of good nutritional status is likely to have healthier babies (Fuchs *et al.*, 2014; Torlesse & Aguayo, 2018). Poor nutritional status was found to be a significant predictor for childhood acute malnutrition. Maternal nutritional status must therefore always be included in the formulation of child undernutrition policies and programmes. Black *et al.* (2013) found that,

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in Asia, the prevalence of low BMI (<18.50) had decreased since 1980, but the rate was almost 10% higher than the worldwide average rate. This study observed that the prevalence of wasting in Bangladesh had increased as a consequence of the decline in mothers' average BMI. Several similar studies have illustrated that low maternal BMI is related to acute undernutrition in children (Rayhan & Khan, 2006; Rahman *et al.*, 2009; Demissie & Worku, 2013; Rahman, 2015; Chowdhury *et al.*, 2016; Habyarimana, 2016; Akombi *et al.*, 2017; Das & Gulshan, 2017). Das and Gulshan (2017) found that the children of mothers with a BMI < 18.50 were at 2.14 times higher risk of being wasted than those of mothers with BMI > 25.50. Rayhan and Khan (2006) estimated that the children of mothers with a BMI > 18.50 were 40% less likely to be wasted than those of mothers with BMI < 18.50. Chowdhury *et al.* (2016) found similar results.

This study was designed to identify whether there was a relationship between mother's education and the likeliness of children being wasted. The findings suggest that maternal education is not an underlying factor for wasting among under-5 children in the study context. This is consistent with the findings of some previous studies (Rayhan & Khan, 2006; Souza *et al.*, 2012; Alom *et al.*, 2012; Fuchs *et al.*, 2014; Mohsena *et al.*, 2017; Pravana *et al.*, 2017; Khan *et al.*, 2017; Musa *et al.*, 2017) but inconsistent with others (Phengxay *et al.*, 2007; Meshram *et al.*, 2012; Demissie & Worku, 2013; Mishra *et al.*, 2014; Olita'a *et al.*, 2014; Rabbi & Karmaker, 2015; Ambadekar & Zodpey, 2017). Also, paternal education was not found to be a significant risk factor for acute undernutrition in children, which is consistent with some previous studies (Phengxay *et al.*, 2007; Souza *et al.*, 2012; Mishra *et al.*, 2014; Ambadekar & Zodpey, 2017; Khan *et al.*, 2017) but inconsistent with others (Meshram *et al.*, 2012; Olita'a *et al.*, 2014; Pravana *et al.*, 2017; Musa *et al.*, 2017).

This study has also demonstrated that wealth index, as expected, plays a notable role in child undernutrition. This is consistent with previous research, which has found that the odds of being wasted are higher among the children of poor families than those of rich families (Meshram *et al.*, 2012; Rabbi & Karmaker, 2015; Mishra *et al.*, 2014; Fuchs *et al.*, 2014; Habyarimana, 2016; Ambadekar & Zodpey, 2017; Pravana *et al.*, 2017; Khan *et al.*, 2017). The results of this study have established that, in 2014, children from poor families were at about 1.50 times higher risk of being severely wasted than children from rich families. Lower economic status is undoubtedly related to some issues closely linked to wealth index that would enhance acute undernutrition among under-5 children, because inadequacy of wealth means inadequacy of basic amenities, such as education, health services, food and shelter (Ambadekar & Zodpey, 2017). Diseases such as fever and diarrhoea frequently occur in poor families and lead to childhood undernutrition (Ortiz *et al.*, 2014; Ambadekar & Zodpey, 2017). Ortiz *et al.* (2014) and Musa *et al.* (2017) have argued that poor access to health services can be related to acute undernutrition.

Study strengths and limitations

The main strength of this study is that the data were of national level. Given this, the findings will help the Bangladeshi authorities formulate appropriate national-level policies and programmes to reduce wasting among under-5 children. At the same time, it assessed divisional differences in child nutritional, so immediate action can be taken at a divisional level and where needs are most pressing. However, the study has its limitations. First, although this was a cross-sectional study, due to a lack of recent data it was not possible to compare the 2014 data with the prevailing situation in Bangladesh. Second, only certain covariates were considered. Third, there were missing values in some covariates, which might have affected the results. Finally, some relevant variables, such as breastfeeding practice and antenatal visits, were not included in the study.

Conclusions and policy implications

This study of acute undernutrition among under-5 children in Bangladesh offers insight into the broader state of child health in Bangladesh. Because nutritional status is considered a measure of

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quality of life and freedom from disease, although Bangladesh outperformed the relevant MDGs, the persistent widespread prevalence of child wasting is deeply troubling. To succeed in reducing acute child undernutrition, organized long-term and short-term efforts must be undertaken in the country. Interventions must target economic empowerment and short-term nutrition supplements for people of disadvantaged economic status. In addition, the government should collaborate with different international or national-level non-profit organizations to carry out programmes alongside ongoing government programmes. Furthermore, parents need better access to health information and education, and to this end community-based health service facilities should be promoted at the grassroots level.

This study puts forward some of the leading risk factors for acute child undernutrition in Bangladesh. Policies and programmes aimed at eradicating acute child undernutrition need to address these determinants. The findings of this research may be used to inform other countries where child undernutrition exists.

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Ethical Approval. This study was based on an analysis of existing public domain survey datasets that are freely available online with all identifier information removed. The survey was approved by the Ethics Committee in Bangladesh. The authors were granted permission to use of the data for independent research purposes.

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