

Review Article

Risk or associated factors of wasting among under-five children in Bangladesh: A systematic review

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Background and Objectives: Wasting among under-five years old (U-5) children is a significant global public-health-nutrition burden. To effectively address this problem in Bangladesh, knowing its prevalence, causes and associated-factors are essential. This review aimed to identify evidences available in the existing-accessible literature/documents that describe the individual, socioeconomic, demographic, and contextual risk-factors associated with wasting among U-5 children in Bangladesh. **Methods and Study Design:** Electronic-databases included were MEDLINE, EMBASE, CINAHL, WoS, and Cochrane-Library written in English and published until 29 February 2024. **Results:** The search from the five databases yielded 167 publications. Of these, 50 papers/articles were duplicates and 108 were irrelevant, and nine have met the inclusion criteria. Additionally, 22 articles/documents were identified from other sources. Finally, a total of 31 articles/documents have been included in this review. The odds of childhood wasting observed were high for smaller birth-size, higher birth-order, male child, 12-24 months age-group, improper breastfeeding- and complementary-feeding practices, not-receiving DPT1 and/or measles vaccine, ≥ 1 sibling(s), maternal-undernutrition, less food-consumption during pregnancy, lack of maternal-education, lack of hand-washing practices by the mother/caregiver, paternal tobacco use, lower socioeconomic-status, food-insecurity, lack of access to hygienic-latrines and/or improved-water, Monsoon season (May-August), flood exposure, living especially in Barishal, Rajshahi Chittagong and Rangpur-division and/or Eastern part of Bangladesh, and urban-slum. **Conclusions:** The risk/associated factors of wasting among U-5 children in Bangladesh were found at various multilevel. Rarely caused by any one factor alone, wasting in U-5 children results from an interplay between pregnant-mother's health and nutrition, child-caring practices, diets, poverty, and disease, which vary by context.

Key Words: risk factors, associated factors, wasting, under-five children, Bangladesh

INTRODUCTION

Wasting defined by weight-for-length or height (WLZ/WHZ) < -2 z-score among children under five years (U-5 children) or mid-upper-arm-circumference (MUAC) < 125 mm among 6-59 months age group is a significant global nutritional and public health burden in Bangladesh. Wasting makes children too thin and weak, and puts the children at higher risk of illnesses; wasting also leads to poor growth, development, and learning, and dying. In 2020, globally, 45.4 million U-5 children were wasted, 14.3 million were severely wasted (WLZ/WHZ < -3), and more than half of all children affected by wasting lived in Southern Asia.¹ Worldwide, 2.6 million children die each year due to malnutrition, and 45% of U-5 deaths were due to undernutrition.^{2, 3} Around 13% of worldwide deaths were attributed to wasting in 2015, representing 875,000 preventable child deaths.³ Childhood wasting rate has been reducing slowly at a global level including in Bangladesh over the past 40 years; but some

countries such as India and Sri Lanka, recently noted rising prevalence rates.⁴ An estimate highlighted that approximately 150,000 child deaths could be averted by reducing the increasing rate of wasting.⁵ Over almost two decades, reduction of child wasting prevalence in Bangladesh has been very slow with national prevalence of 15% in 2004, 16% in 2011, and 17% in 2014.⁶ Nevertheless, the prevalence rate is still not acceptable. Latest data from Bangladesh showed that, although child wasting prevalence is declining, it is still very high, ranging from

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8.4%⁷ to 9.8%.⁸ There is no nationwide estimation of wasting status in U-5 children in Bangladesh after 2019 nor after the Covid-19 pandemic. However, following the global estimates on the impact of Covid-19 on nutrition, the prevalence of wasting was expected to be increased from the recent report of UNICEF. Analysis, based on these estimates applied to 118 low- and middle income-countries, suggested that there could be a 14.3% increase in the prevalence of moderate or severe wasting among U-5 children due to COVID-19-related predicted country-specific losses in GNI per capita. We estimate this would translate to an additional of 6.7 million children with wasting in 2020; an estimated 57.6% of these children are in south Asia and an estimated 21.8% in sub-Saharan Africa⁹

Many factors are yet to be known about the etiology or risk factors of malnutrition, including childhood wasting, which would help to target and formulate more cost-effectiveness interventions to reduce and prevent them. An array of risk or associated factors have been studied, lending support to nutrition-specific and nutrition-sensitive interventions in the context of health system strengthening; however, the importance of these risk or associated factors varies widely between studies and environments.³ A detailed understanding of the main determinants of wasting particularly in the U-5 population of Bangladesh could help with national strategies against childhood wasting and will contribute to the scientific understanding of wasting in these populations in low-resource settings.

METHODS

This review identified evidence available in existing accessible literature and documents that describe the individual, socioeconomic, demographic, and contextual risk factors associated with wasting among U-5 children in Bangladesh. We conducted a systematic search of the electronic databases. Search included PubMed (MEDLINE), EMBASE (OVID platform), Cumulative Index to Nursing and Allied Health Literature (CINAHL), Web of Science (WoS), and Cochrane Library. Only articles written in English and published before 29 February 2024 were reviewed.

Search string used: (acute undernutrition) OR (acute malnutrition) (Wasting*) OR (low weight-for-height) OR (low weight-for-length) OR (causes of wasting) OR (malnutrition) OR (malnourished) OR (child nutrition disorders) OR (MUAC less than 125 mm) AND (risk factor*) OR (associated factor*) AND (under-five children) OR (less than five years old children) AND Bangladesh.

We also used a snowball technique to identify additional relevant references from retrieved sources. Two investigators (MIH, and SH) reviewed each search result following the inclusion and exclusion criteria as follows: (1) the risk or associated factors of wasting in U-5 children were described in the articles and documents, and (2) information/data used were from Bangladesh. Exclusion criteria included studies that only described the risk or associated factors of underweight and or stunting but not of wasting, and do not contain data on Bangladeshi U-5 children. If an assessment of the suitability of the article

was indeterminate based on the abstract and title, the full-text article was sought.

We reviewed the total number of papers, articles and documents retrieved and duplicates were excluded. Discrepancies between investigators' (MIH and SH) inclusion and exclusion determinations were uncommon (<5% of the total included articles) and lessened as the process progressed. When needed, these two investigators (MIH and SH) judged the differences in determinations during meetings with the other co-authors.

We conducted the review methods and reporting procedures following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement¹⁰ described in the PRISMA flowchart (Figure 1). The search from the five databases yielded 167 publications. Of these, 50 papers/articles were found to be duplicates and 108 were identified as irrelevant and the remaining 9 have met inclusion criteria. Additionally, 22 articles/documents were identified from other sources (e.g. searching the cross-references and from the Google search engine). Finally, a total of 31 papers/articles/documents were included in this review.

RESULTS

The list of total 31 papers/articles considered for this review were displayed in Table 1. The name of the lead author and year of publication, data sources, number of samples and age group of children studied, and the risk or associated factors of wasting (WLZ/WHZ <-2 and/or MUAC <125 mm) with the strength of association adjusting the covariates (other factors) were listed.

Table 2 to Table 5 depicted the various risk or associated factors that are significant after statistical calculation. Risk or associated factors found significant were as follows:

Children's own factors (Table 2)

Three of the 31 papers and articles reported a significant association of child wasting with birth size and birth order. Very small birth size (odds ratio (OR): 4.3) or smaller than average birth size (OR: 1.7 to 2.7), and (if birth weight was known then) low birth weight (baby's birth weight <2500 g) (OR:1.7), were found as risk factors of child's wasting. Similarly, higher birth order (3+) was found as another risk factor for childhood wasting (OR: 1.2 to 3.1). Only one study found a significant association between childhood stunting with wasting (OR: 1.2).

Eight studies revealed a significant association between the sex of the child with wasting. Among them, only one reported being female as a risk factor for wasting (OR: 1.4), the other six studies found male children as a risk factor for childhood wasting (OR: 1.2 to 1.5).

At least 10 of these 30 reviewed papers and articles reported a significant association of age of the child with wasting. Among the different age groups, the highest proportion of wasted children was found in <24 months old children, particularly in 12 to 23 months age group (OR: 8.8). Some other studies also reported higher odds (ranging from 1.1 to 4.0) of wasting in > 24 months age group.

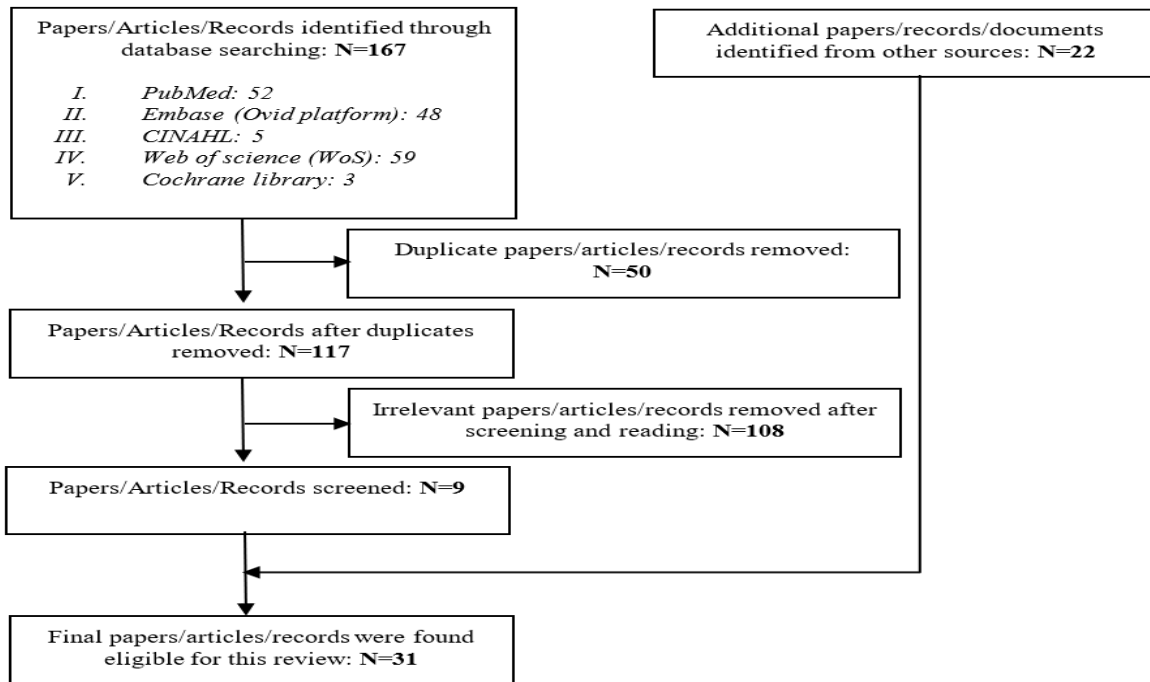


Figure 1. The PRISMA flowchart

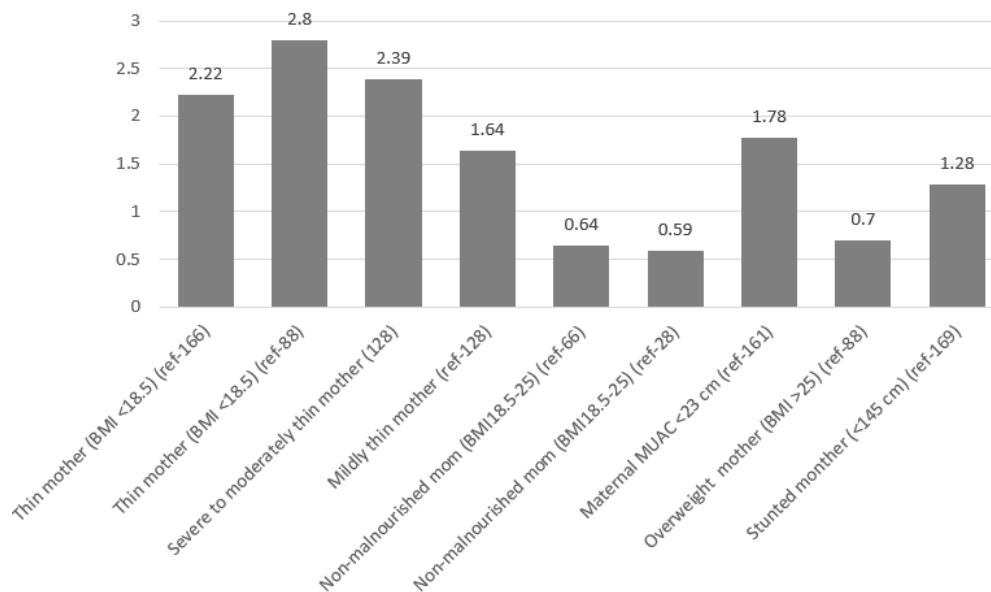


Figure 2. Wasting status of under-5 children by their mother's nutritional status

A total of 6 of the 31 reviewed papers and articles reported a significant association of breastfeeding practices or status of the child with her/his wasting. Five of these 6 studies reported that better breastfeeding practices were found as a protective factor of wasting. If predominant breastfeeding was stopped before 4 months of age, the risk of child's wasting also rapidly increased (OR: 2.7). For 6 to 59 months age group, fulfillment of minimum dietary diversity (MDD) (consuming 4 or more food groups in last 24 h) were found to be protective against childhood wasting (OR: for both 0.8). Similarly, not receiving more than 4 food groups was found as a significant risk factor for wasting (OR: 1.5).

Child vaccination was found to be significantly associated with wasting status of children in two studies. Not receiving DPT1 vaccine (OR: 1.8) and measles vaccine (OR: 1.6) was found as a risk factor for wasting in children. The odds of receiving any medicine/drop on the day preceding the survey were 67% higher ($p < 0.001$) among wasted than non-wasted children. Illness during previous two weeks was found as a risk factor (OR: 3.1) for wasting. A negative association (Coefficient: -0.1, $p = 0.046$) between WHZ and Shigella was reported in one study.

Table 1. The list of total 30 papers and articles that have been considered for this review

Trial name	Data taken from or type of study	Population	Sample size	Dependent variable: wasting (WHZ < -2 or MUAC <125 mm)	Findings on the associated/risk factors Odds Ratio (95% CI), <i>p</i> -value
Das et al (2021) ¹⁵⁹	Data were extracted from the Global Enteric Multicentre Study	< 5 years male and female children	2,788	WHZ <-2	- Shigella infection: -0.11 (-0.21 to - 0.001), <i>p</i> =0.046 - Campylobacter positive diarrhoea: 0.22: (0.08 - 0.37), 0.003
Ghosh et al. (2021) ¹⁶⁰	Cross-sectional study in rural Noakhali; December 2019 to February 2020	< 5 years Male and Female children	108	WHZ <-2	OR (95% CI), <i>p</i> -value No hand washing before feeding the baby OR: 1.51, <i>p</i> <0.006
Haque et al (2021) ¹⁶¹	Cross-sectional	< 2 years Male and Female children	5,069 households	WHZ <-2	Maternal MUAC <23: 1.78 (1.50-2.12); <i>p</i> < 0.001.
Rahman et al (2021) ¹⁶²	This work utilized malnutrition data that was derived from Bangladesh Demographic and Health Survey which was conducted in 2014.	< 5 years Male and Female children	7,079	WHZ <-2	- Barisal: 1.56 (1.21–2.02), <i>p</i> <0.05 - Chittagong: 1.40 (1.11-1.77), <i>p</i> <0.05 - Rajshahi: 1.50 (1.16–1.93), <i>p</i> <0.05 - Rangpur: 1.31 (1.01–1.69), <i>p</i> <0.05 - Male child: 1.17 (1.03–1.33), <i>p</i> <0.05 - Age < 12 months: 1.38 (1.22-1.58), <i>p</i> <0.05 - Poor: 1.38 (1.14–1.68), <i>p</i> <0.05
Talukder et al (2021) ¹⁶³	This study extracted necessary information from Bangladesh Urban Health Survey (BUHS) 2013	< 5 years Male and Female children	10,511	WHZ <-2	- Age > 48 months: 1.14 (1.04-1.32), <i>p</i> <0.01 Mother's education up to: - Primary: 0.75 (0.63-0. 95), <i>p</i> <0.001 - Secondary or higher: 0.58 (0.48-0. 98), <i>p</i> <0.001 - Wealth index, middle (compared to poor): 0.82 (0.76-0.90), <i>p</i> <0.001 - Wealth index, rich (compared to poor): 0.58 (0.40-0.94), <i>p</i> <0.001 - ANC services: 0.83 (0.53-0.94), <i>p</i> <0.05 - Breast fed: 0.43 (0.42-0.95), <i>p</i> <0.01 - City-corporation slum (compared to other city areas): 1.35 (1.04-1.45), <i>p</i> <0.001

Table 1. The list of total 30 papers and articles that have been considered for this review (cont.)

Trial name	Data taken from or type of study	Population	Sample size	Dependent variable: wasting (WHZ < -2 or MUAC <125 mm)	Findings on the associated/risk factors Odds Ratio (95% CI), <i>p</i> -value
Rahman et al (2020) ¹⁶⁶	Bangladesh Demographic Health and Survey conducted in 2014.	< 5 years Male and Female children	7,131	WHZ<-2 to -3 WHZ <-3	For moderate wasting - Barisal: 1.57 (1.16–2.11), <i>p</i> =0.003 - Rajshahi: 1.64 (1.22–2.19), <i>p</i> =0.001 - Rural: 1.23 (1.01–1.50), <i>p</i> =0.035 - Less than average birth size: 1.65 (1.32–2.05), <i>p</i> <0.001 - Thin mother (BMI 18.5): 2.22 (1.70–2.91), <i>p</i> <0.001 - Non-malnourished (BMI 18.5): 2.22 (1.70–2.91), <i>p</i> <0.001 For severe wasting - Barisal: 2.11 (1.37–3.24), <i>p</i> =0.001 - Rajshahi: 1.64 (1.22–2.19), <i>p</i> =0.001 - Rural: 1.23 (1.01–1.50), <i>p</i> =0.035 - Less than average birth size: 1.65 (1.32–2.05), <i>p</i> <0.001 - Thin mother (BMI 18.5): 2.22 (1.70–2.91), <i>p</i> <0.001 - Male child: 1.48 (1.18–1.86), <i>p</i> =0.001 - Less than average birth size: 1.74 (1.28–2.36), <i>p</i> <0.001 - No measles vaccine: 1.58 (1.14–2.17), <i>p</i> =0.005 - Thin mother (BMI 18.5): 1.45 (1.00–2.11), <i>p</i> =0.048 - Poor: 1.51 (1.06–2.14), <i>p</i> =0.019
Raihan et al (2020) ²⁶	Data used from Suchana program, a large-scale, 7-year nutrition program serving around 250,000 poor households in north-east Bangladesh; the program began in 2015 and will reach around 1.7 million people in the Sylhet and Moulvibazar districts.	6-23 months old Male and Female children	4,400	WLZ <-2	- Asset index, 3 rd quintile: 0.65 (0.47–0.93), <i>p</i> =0.018 - Maternal BMI: 0.91 (0.87–0.95), <i>p</i> <0.001 - More than usual maternal food consumption status during last pregnancy: 0.80 (0.64–0.98), <i>p</i> =0.031 - Usual maternal food consumption status during last pregnancy: 0.75 (0.59–0.95), <i>p</i> =0.020

Table 1. The list of total 30 papers and articles that have been considered for this review (cont.)

Trial name	Data taken from or type of study	Population	Sample size	Dependent variable: wasting (WHZ < -2 or MUAC <125 mm)	Findings on the associated/risk factors Odds Ratio (95% CI), <i>p</i> -value
Raihan et al (2020) ²⁶	Data used from Suchana program, a large-scale, 7-year nutrition program serving around 250,000 poor households in north-east Bangladesh; the program began in 2015 and will reach around 1.7 million people in the Sylhet and Moulvibazar districts.	6-23 months old Male and Female children	4,400	WLZ <-2	- If mother knows diarrheal management: 0.51 (0.30-0.87), <i>p</i> =0.014 - Female child: 0.72 (0.58-0.89), <i>p</i> =0.003 - Child received any medicine or vitamin – drop on the day preceding the survey: 1.67 (1.30-2.13), <i>p</i> <0.001
Hoq et al (2019) ¹⁶⁷	Mixed Method matched case control in the Kurigram district of Bangladesh.	6-59 months old Male and Female children	Case-52 Control-95	WHZ <-2 and/or MUAC 125 mm	- Birth order (first child): 0.3 (0.09-0.96), <i>p</i> =0.042 - Number of family members: 1.30 (1.02-1.65), <i>p</i> =0.033 - Illness in the last 2 weeks: 3.08 (1.13-8.42), <i>p</i> =0.028 - Access to hygienic latrine: 0.25 (0.07-0.82), <i>p</i> =0.022
Sheikh et al (2019) ¹⁶⁸	Bangladesh Demographic and Health Survey (BDHS) 2014	< 2 years Male and Female children		WLZ <-2	- Received minimum dietary diversity: 0.78 (0.59-1.04), <i>p</i> <0.01 - Received minimum meal frequency: 0.78 (0.61-0.99), <i>p</i> <0.01
Khatun et al (2019) ¹⁶⁹	Bangladesh Demographic and Health Survey (BDHS) 2004, 2007, 2011, & 2014	< 5 years Male and Female children	28,123	WLZ <-2	Every 1 cm increase in maternal height significantly reduced the risk of wasting (RR = 0.986 (0.980, 0.992) and severe wasting (RR = 0.984 (0.971, 0.997)). The children of the short statured mothers (<145 cm) had 1.28 (1.14-1.43) times the risk of wasting, and 1.43 (1.11-1.83) times the risk of severe wasting than the tall mothers (≥155 cm).
Harding et al (2018) ⁸⁸	Bangladesh Demographic and Health Survey (DHS) 2014	< 5 years Male and Female children	6,965	WHZ <-2	- Rural: 1.24 - Lack of improved water: 1.78 - Thin mother (BMI <18.5): 1.56 - Overweight mother (BMI >25): 0.70 - Male child: 1.18 - Age > 12 months: 0.60 - Stunted child: 1.2 - Barisal: 1.36 (1.02, 1.81) - Rajshahi: 1.42 (1.07, 1.88)

Table 1. The list of total 30 papers and articles that have been considered for this review (cont.)

Trial name	Data taken from or type of study	Population	Sample size	Dependent variable: wasting (WHZ < -2 or MUAC <125 mm)	Findings on the associated/risk factors Odds Ratio (95% CI), <i>p</i> -value
Hossain et al (2018) ¹⁷⁰	Using data of Bangladesh Demographic Health Survey (2014)	< 5 years Male and Female children	7,173	WHZ<-2	Percentage, <i>p</i> -value - Wasting rate was highest in Barisal division (17.74 %) and lowest in Dhaka division (12.01%), <i>p</i> =0.001 - Wasting rate gradually increased with decreasing of wealth quintile: higher in lowest quintile (17.1%) vs. lowest in highest quintile (11.78%), <i>p</i> =0.008 - Wasting rate was highest in younger age group and gradually decreased up to 48 months of age, <i>p</i> =0.004 - Wasting rate was highest if mother was undernourished (BMI <18.5), <i>p</i> <0.001
Islam et al (2018) ¹⁷¹	Cohort study	< 6 months Male and Female children	154	WLZ <-2	- Age of the infant: 0.27 (0.16–0.44), <i>p</i> <0.001 - Exclusive breastfeeding during 4–8 weeks of age (compared to who stopped earlier): 0.04 (0.004–0.36), <i>p</i> =0.005 - Schooling years of mother: 0.83 (0.71–0.97), <i>p</i> =0.02 - access to household electricity: 0.27 (0.09–0.81), <i>p</i> =0.02
Mohsena et al (2018) ¹⁷²	Data were from a longitudinal data set comprising a nationally representative data sample collected in 2014 and the Food Security Nutrition Surveillance Project (FSNSP) conducted in 2011 and 2012.	< 5 years Male and Female children	Number of households in different years of sampling: 1988 (N = 1231), 2000 (N = 1872), 2014 (N = 2896)	WHZ<-2	- Post-Amon harvest season (January–April): 0.74 (0.66–0.83), <i>p</i> <0.001 - Post-Aus harvest season (September–December): 0.76 (0.68–0.85), <i>p</i> <0.001 - Eastern hills agro-ecological zone: 0.83 (0.70–0.99), <i>p</i> <0.05 - Birth season of the child was not associated with childhood wasting.

Table 1. The list of total 30 papers and articles that have been considered for this review (cont.)

Trial name	Data taken from or type of study	Population	Sample size	Dependent variable: wasting (WHZ < -2 or MUAC <125 mm)	Findings on the associated/risk factors Odds Ratio (95% CI), <i>p</i> -value
Choudhury et al (2017) ¹²⁸	October 2011 to November 2013 through the Food Security Nutritional Surveillance Project in Bangladesh	< 24 months	10,291	WLZ < -2	<p><6 months age group</p> <ul style="list-style-type: none"> - Child age: 0.86 (0.75–0.97), <i>p</i>=0.017 - Not exclusively breast fed: 1.79 (1.23–2.61), <i>p</i>=0.003 - Severe to moderately thin mother: 1.97 (1.12–3.47), <i>p</i>=0.019 - Mildly thin mother: 1.57 (1.03–2.38), <i>p</i>=0.034 - No dietary diversity (≤4 food groups): 1.49 (1.02–2.19), <i>p</i>=0.041 <p>6-11 months age group:</p> <ul style="list-style-type: none"> - Child age: OR: 1.1 (1.02–1.19), <i>p</i>=0.014 - Severe to moderately thin mother: 2.39 (1.67–3.44), <i>p</i><0.001 - Mildly thin mother: 1.64 (1.15–2.34), <i>p</i>=0.007 - Severe food insecurity: 1.41 (1.04–1.91), <i>p</i>=0.025 - For drinking use of surface water: 0.5 (0.26–0.95), <i>p</i>=0.035 <p>12-23 months age group:</p> <ul style="list-style-type: none"> - Monsoon season: 1.45 (1.15–1.84), <i>p</i>=0.002 - Illiterate mother: 1.53 (1.05–2.23), <i>p</i>=0.028 - Severe to moderately thin mother: 2.11 (1.68–2.65), <i>p</i><0.001 - Mildly thin mother: 1.38 (1.11–1.72), <i>p</i>=0.004 - Less food consumption during pregnancy: 1.25 (1.03–1.52), <i>p</i>=0.025 - Having non-hygienic latrine: 1.36 (1.04–1.78), <i>p</i>=0.025 - Moderate food insecurity: 1.66 (1.12–2.46), <i>p</i>=0.011 - Severe food insecurity: 1.34 (1.09–1.63), <i>p</i>=0.005

Table 1. The list of total 30 papers and articles that have been considered for this review (cont.)

Trial name	Data taken from or type of study	Population	Sample size	Dependent variable: wasting (WHZ < -2 or MUAC <125 mm)	Findings on the associated/risk factors Odds Ratio (95% CI), <i>p</i> -value
Hasan et al (2016) ¹⁷³	Cross-sectional nationally representative BDHS surveys (1996-2011)	< 5 years Male and Female children	28,941	WHZ <-2	RR: ((95% CI), <i>p</i> -value Mothers with secondary or higher education: 0.82 (0.74, 0.91)
Chowdhury et al (2016) ⁶⁶	Using data of Bangladesh Demographic Health Survey (2011)	< 5 years Male and Female children	7,568	WLZ < -2	Non-malnourished mother (BMI18.5-25): 0.64 (0.55-0.76), <i>p</i> < 0.001 Overweight mother (BMI >25): 0.35 (0.26-0.48), <i>p</i> < 0.001 Living in eastern region of Bangladesh: 1.37 (1.02-1.84), <i>p</i> =0.037
Rahman et al (2016) ¹⁴	Data on child nutrition has been extracted from a nationally representative sample survey i.e. the Bangladesh Demographic Health Survey (BDHS) 2011 conducted between November 2010 and April 2011.	< 5 years Male and Female children	7,530	WHZ <-2	RR (95 CI), <i>p</i> -value LBW: 1.71 (1.53-1.92), <i>p</i> =<0.05
Das et al, (2015) ¹⁷⁴	Chart analysis from Diarrhoeal Disease Surveillance of icddr,b	< 5 years Male and Female children	16,948	WHZ <-2	≥1 under-5 siblings: 1.12 (1.04, 1.21), <i>p</i> <0.001
Raj et al (2015) ¹⁷⁵	Nationally representative data of Demographic and Health Surveys of Bangladesh (2011), India (2005-6) and Nepal (2011).	< 5 years Male and Female children	Ban: 7,861 Ind: 46,655 Nep: 2,475	WHZ <-2	- Higher birth order (3+): 1.14 (1.04-1.25) - For girls but not boys, number of brothers increased risk for severe wasting: - 1 vs. 0 brothers: 1.31 (1.11-1.55); - 2 vs. 0 brothers: 1.36 (1.07, 1.73)
Fuchs et al (2014) ⁶⁴	Case-control study	< 5 years Male and Female children	449	WHZ <-2	- Child's age >1 year: 3.14 (1.43-6.90), <i>p</i> =0.004 - Predominant breastfeeding stopped before 4 months: 2.67 (1.23-5.80), <i>p</i> =0.013 - Undernourished mother (BMI <18.5): 2.80 (1.20-6.53), <i>p</i> =0.017 - Father with low-paid job: 5.78 (2.54-13.16), <i>p</i> <0.001 - Monthly income < 10000 taka (1 US \$=80 taka): 2.87 (1.31-6.29), <i>p</i> =0.008

Table 1. The list of total 30 papers and articles that have been considered for this review (cont.)

Trial name	Data taken from or type of study	Population	Sample size	Dependent variable: wasting (WHZ < -2 or MUAC <125 mm)	Findings on the associated/risk factors Odds Ratio (95% CI), <i>p</i> -value
Alom et al (2012) ¹⁷⁶	BDHS 2007	< 5 years Male and Female children	6,150	WHZ < -2	- Child age: 12-23 months compared to <6 months age group: 1.51 (1.16-1.97), <i>p</i> <0.01 - Mother's education, Secondary compared to illiterate mother: 0.68 (0.56-0.83), <i>p</i> <0.01 - Mother's education, higher compared to illiterate mother: 0.65 (0.45-0.98), <i>p</i> <0.05 - Father's occupation, labourer compared to agriculture: 0.78 (0.63-0.91), <i>p</i> <0.01 - Currently breast fed: 1.44 (1.17-1.77), <i>p</i> <0.01
Chowdhury et al (2011) ¹⁷⁷	Secondary Data analysis from hospital surveillance system of icddr,b	< 5 years Male and Female children	13,555	WHZ < -2	For moderate wasting - Child age <24 months: 0.73 (0.66-0.81) - Illiterate mother: 1.54 (1.41-1.68) - Lower SES: 2.64 (2.36-2.96) - Middle SES: 1.77 (1.59-1.97) For severe wasting - Child age < 24 months: 0.76 (0.65-0.88) - Illiterate mother: 1.63 (1.43-1.87) - Lower SES: 2.83 (2.35-3.40) - Middle SES: 1.83 (1.52-2.20)
Goudet et al (2011) ¹⁷⁸	This study comprises a secondary analysis of data collected by the International Food Policy Research Institute (IFPRI) (del Ninno, 2001)	< 5 years Male and Female children	757 households	WHZ <-2	Flood exposure: 25.06 (1.81–347.45)
Best et al (2007) ¹⁰⁹	households that participated in the Nutritional Surveillance Project stratified, multistage cluster sample	< 5 years Male and Female children	77,678	WHZ < -2	- For wasting, parental tobacco use: 1.10 (1.03-1.17), <i>p</i> =0.004 - For severe wasting, parental tobacco use: 1.14 (0.98–1.32), <i>p</i> =0.09
Rayhan et al (2006) ²⁸	BDHS1999-2000 Data used: with case-control design	< 5 years Male and Female children	77,678	WHZ < -2	- Birth size of the baby compared to average size: - Very small: 1.885, <i>p</i> <0.001 - Smaller than average: 1.69, <i>p</i> <0.001 - Non-malnourished mother: 0.594, <i>p</i> <0.001
Henry et al (1993) ¹⁷⁹	Case-control study	< 5 years Male and Female children	151	MUAC < 110 mm (Marasmus)	- Children from families with other children under 5 years of age: 2.51 (1.33-4.74) - Consumptions off formulae food: 16.41 (3.39-79.36), <i>p</i> <0.05 - 5 years of schooling of mother: 0.34 (0.15-0.76), <i>p</i> =0.01 - Birth order ≥4: 3.14 (1.59-6.20), <i>p</i> =0.001
Jubayer et al (2022) ¹⁸⁰	Cross-sectional study at St. Martin's Island of Bangladesh	< 5 years male and female children	256	WHZ <-2	- Male child: 2.03 (1.33-3.11), <i>p</i> =0.001 - lowest wealth quintile: 2.88 (1.22-6.77), <i>p</i> =0.015

Table 2. Risk or associated factors of child wasting (those were children's own factors)

Risk or associated factors	Odds Ratio (95% CI), <i>p</i> -value	Reference (respectively)
Birth size		
Very small	4.31 (1.87-9.92), <i>p</i> =0.001	Hossain et al (2020) ¹⁶⁵
Smaller than average	2.67 (1.21-5.81), <i>p</i> =0.014	Hossain et al (2020) ¹⁶⁵
	1.65 (1.32-2.05), <i>p</i> <0.001	Rahman et al (2020) ¹⁶²
	1.69, <i>p</i> <0.001	Rayhan et al (2006) ²⁸
Low birth weight:	1.71 (1.53-1.92), <i>p</i> <0.05	Rahman et al (2016) ¹⁴
Birth order (first child)	0.3 (0.09-0.96), <i>p</i> =0.042	Hoq et al (2019) ¹⁶⁷
Higher birth order (3+)	1.14 (1.04-1.25), <i>p</i> <0.05	Raj et al (2015) ¹⁷⁵
	3.14 (1.59-6.20), <i>p</i> =0.001	Henry et al (1993) ¹⁷⁹
Stunted child	1.20, <i>p</i> <0.05	Harding et al (2018) ⁸⁸
Child's sex		
Female child	1.44 (1.17-1.77), <i>p</i> <0.001	Choudhury et al (2000) ³⁷
	0.68 (0.58-0.79), <i>p</i> <0.001	Chowdhury et al (2020) ¹⁶⁴
	0.75 (0.65-0.87), <i>p</i> <0.001	Hossain et al (2020) ¹⁶⁵
	0.72 (0.58-0.89), <i>p</i> =0.003	Raihan et al (2020) ²⁶
Male child	21.17 (1.03-1.33), <i>p</i> <0.05	Rahman et al (2021) ¹⁶²
	1.48 (1.18-1.86), <i>p</i> =0.001	Rahman et al (2020) ¹⁶⁶
	1.18, <i>p</i> <0.05	Harding et al (2018) ⁸⁸
Age of the child		
<12 months	1.38 (1.22-1.58), <i>p</i> <0.05	Rahman et al (2021) ¹⁶²
	13.34 (8.22-21.63), <i>p</i> <0.001	Choudhury et al (2000) ³⁷
12-23 months	8.77 (5.40-14.26), <i>p</i> <0.001	Choudhury et al (2000) ³⁷
	1.44 (1.18-1.76), <i>p</i> <0.001	Chowdhury et al (2020) ¹⁶⁴
12-23 months	1.51 (1.16-1.97), <i>p</i> <0.001	Alom et al (2012) ¹⁷⁶
<24 months	0.73 (0.66-0.81), <i>p</i> <0.05	Chowdhury et al (2011) ¹⁷⁷
24-35 months	3.95 (2.40-6.52), <i>p</i> <0.001	Choudhury et al (2000) ³⁷
36-48 months	1.87 (1.03-3.40), <i>p</i> <0.001	Choudhury et al (2000) ³⁷
>48 months	1.14 (1.04-1.32), <i>p</i> <0.01	Talukder et al (2021) ¹⁶³
>12 months	0.60, <i>p</i> <0.05	Harding et al (2018) ⁸⁸
	3.14 (1.43-6.90), <i>p</i> =0.004	Fuchs et al (2014) ⁶⁴
Child feeding		
Breast feeding	0.43 (0.42-0.95), <i>p</i> <0.01	Talukder et al (2021) ¹⁶³
Exclusive breastfeeding during 4-8 weeks of age	0.04 (0.004-0.36), <i>p</i> =0.0005	Islam et al (2018) ¹⁷¹
Predominant breastfeeding stopped before 4 months	2.67 (1.23-5.80), <i>p</i> =0.013	Fuchs et al (2014) ⁶⁴
Not exclusively breast fed:	1.79 (1.23-2.61), <i>p</i> =0.003	Choudhury et al (2017) ¹²⁸
Consumptions of formulae food	16.41 (3.39-79.36), <i>p</i> <0.05	Henry et al (1993) ¹⁷⁹
Older child's food related variables		
Received minimum dietary diversity	0.78 (0.59-1.04), <i>p</i> <0.01	Sheikh et al (2019) ¹⁶⁸
No dietary diversity (≤ 4 food groups)	1.49 (1.02-2.19), <i>p</i> =0.041	Choudhury et al (2017) ¹²⁸
Received minimum meal frequency	0.78 (0.61-0.99), <i>p</i> <0.01	Sheikh et al (2019) ¹⁶⁸
Child's vaccination		
Non-receiving DPT1	1.82 (1.45-2.28), <i>p</i> <0.001	Choudhury et al (2000) ³⁷
No measles vaccine	1.58 (1.14-2.17), <i>p</i> =0.005	Rahman et al (2020) ¹⁶⁶
Child received any medicine/drop on the day preceding the survey	1.67 (1.30-2.13), <i>p</i> <0.001	Raihan et al (2020) ²⁶
Illness in the last 2 weeks	3.08 (1.13-8.42), <i>p</i> =0.028	Hoq et al (2019) ¹⁶⁷
Shigella infection:	Coefficient: 0.11 (-0.21- -0.001)	Das et al (2021) ¹⁵⁹

Siblings and parental factors (Table 3)

Having one or more siblings was found as an associated factor of wasting of the index child in 3 studies (OR: ranging from 1.1 to 2.5). For girls (but not boys), the number of male siblings increased the risk for severe wasting (OR: 1.3).

Ten of these 31 reviewed papers and articles reported a significant association between maternal nutritional status with child wasting (Figure 2). Thinner or undernourished mothers were found as risk factor for their children's wasting. An increase of one cm in maternal height significantly reduced the risk of wasting (RR = 0.986 (0.980, 0.992) and severe wasting (RR = 0.984; (0.971, 0.997)). The children of short-statured mothers (<145 cm) had 1.3 times higher risk of wasting and 1.4 times higher risk of

severe wasting than tall mothers (≥ 155 cm). Food consumption during pregnancy was also a significant risk factor for the wasting status of the index child. During pregnancy, food consumption more than usual was found as protective (OR: 0.8) and less food consumption was found as a risk factor (OR: 1.3) for child wasting.

Seven studies found that all levels (from primary to higher study) of maternal education were protective against childhood wasting (Figure 5). Moreover, illiteracy of the household head was also found as a significantly associated factor of a child's wasting status. The presence of mothers' knowledge of diarrheal management was found as a significant protective factor for childhood wasting. Lack of hand-washing practices by the mother/caregiver before feeding the baby was significantly

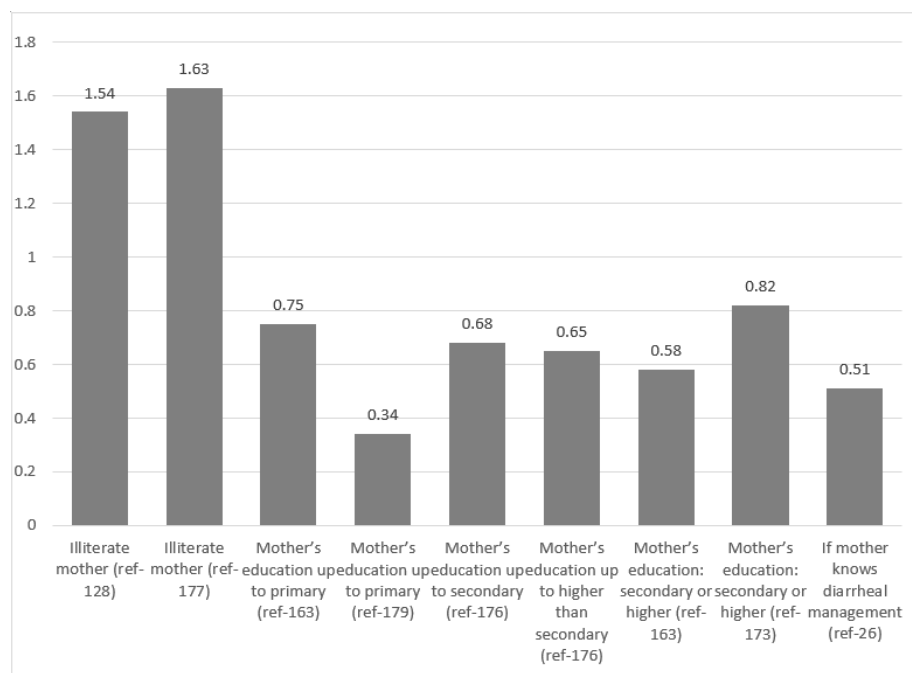


Figure 3. Wasting status of under-5 children by their mother's education status

Table 3. Siblings and parent-related risk or associated factors of child wasting

Risk or associated factors	Odds Ratio (95% CI), <i>p</i> -value	Reference (respectively)
Under-5 siblings: ≥ 1	1.09 (1.01-1.18), <i>p</i> =0.032 1.12 (1.04-1.21), <i>p</i> <0.001 2.51 (1.33-4.74)	Hossain et al (2020) ¹⁶⁵ Das et al. (2015) ¹⁷⁴ Henry et al (1993) ¹⁷⁹
For girls but not boys, the number of brothers increased the risk of severe wasting	1.31 (1.11-1.55), <i>p</i> <0.05	Raj et al (2015) ¹⁷⁵
Maternal nutrition status		
Maternal BMI	0.91 (0.87-0.95), <i>p</i> <0.001	Raihan et al (2020) ²⁶
Thin mother (BMI <18.5)	2.22 (1.70-2.91), <i>p</i> <0.001 1.56, <i>p</i> <0.05 2.80 (1.20-6.53), <i>p</i> =0.017	Rahman et al (2020) ¹⁶⁶ Harding et al (2018) ⁸⁸ Fuchs et al (2014) ⁶⁴
Severe to moderately thin mother	2.39 (1.67-3.44), <i>p</i> <0.001	Choudhury et al (2017) ¹²⁸
Mildly thin mother	1.64 (1.15-2.34), <i>p</i> =0.007	Choudhury et al (2017) ¹²⁸
Non-malnourished mother (BMI 18.5-25)	0.64 (0.55-0.76), <i>p</i> <0.001	Chowdhury et al (2016) ⁶⁶
Maternal MUAC <23 cm	0.594, <i>p</i> <0.001	Rayhan et al (2006) ²⁸
Overweight mother (BMI >25)	1.78 (1.5-2.12), <i>p</i> <0.001	Haque et al (2021) ¹⁶¹
Maternal height	0.70, <i>p</i> <0.05	Harding et al (2018) ⁸⁸
	RR: Moderate wasting = 0.986 (0.980-0.992) Severe wasting = 0.984 (0.971-0.997)	Khatun et al., 2019 ¹⁶⁹
Short-statured mothers (<145 cm) compared to tall mothers (≥ 155 cm)	RR: Moderate wasting = 1.28 (1.14-1.43) Severe wasting = 1.43 (1.11-1.83)	Khatun et al., 2019 ¹⁶⁹
Maternal food consumption		
More than usual maternal food consumption status during the last pregnancy	0.80 (0.64-0.98), <i>p</i> =0.031	Raihan et al (2020) ²⁶
Less food consumption during pregnancy	1.25 (1.03-1.52), <i>p</i> =0.025	Choudhury et al (2017) ¹²⁸
Maternal education		
Schooling years of mother	0.83 (0.71-0.97), <i>p</i> =0.02	Islam et al (2018) ¹⁷¹
Illiterate mother	1.54 (1.41-1.68), <i>p</i> <0.05 1.63 (1.43-1.87), <i>p</i> <0.05	Choudhury et al (2017) ¹²⁸ Chowdhury et al (2011) ¹⁷⁷
Mother's education up to primary	0.75 (0.63-0.95), <i>p</i> <0.001 0.34 (0.15-0.76), <i>p</i> =0.01	Talukder et al (2021) ¹⁶³ Henry et al (1993) ¹⁷⁹
Mother's education up to Secondary	0.68 (0.56-0.83), <i>p</i> <0.01	Alom et al (2012) ¹⁷⁶
Mother's education: higher	0.65 (0.45-0.98), <i>p</i> <0.05	Alom et al (2012) ¹⁷⁶
Mother's education: secondary or higher	0.58 (0.48-0.98), <i>p</i> <0.001 0.82 (0.74, 0.91), <i>p</i> <0.05	Talukder et al (2021) ¹⁶³ Hasan et al (2016) ¹⁷³
No education of household head	1.59 (1.16-2.18), <i>p</i> <0.001	Choudhury et al (2000) ³⁷
If the mother knows diarrheal management:		
No hand washing by the mother/caregiver before feeding the baby	0.51 (0.30-0.87), <i>p</i> =0.014 1.51, <i>p</i> <0.006	Raihan et al (2020) ²⁶ Ghosh et al. (2021) ¹⁶⁰
Parental tobacco use	1.10 (1.03-1.17), <i>p</i> =0.004	Best et al (2007) ¹⁰⁹

associated (OR: 1.5) to childhood wasting. Parental tobacco use was reported as a significant risk factor (OR: 1.1) that exacerbated the child's wasting status.

Socioeconomic factors (Table 4)

Seven studies reported that the wasting rate gradually increased with decreasing wealth quintile i.e. highest in the lowest quintile. Thus, middle-class, upper-middle-class and upper-class economic conditions were found as significant protective factors, and lower-middle-class and lower-class economic conditions were found as significant risk factors for child wasting as well as other forms of undernutrition. Fathers with a low-paid job were found as a significant risk factor (OR: 5.8) for child wasting. Similarly, a monthly family income of less than 10,000 taka (USD 1 = BDT 80 during the study period) was also a risk factor (OR: 2.9) for childhood wasting.

Food insecurity (either moderate or severe) was also found as a significant risk factor for child wasting (OR: 1.3 to 1.7) in one study. Access to a hygienic latrine was a protecting factor (OR: 0.3) and not having any hygienic latrine was found as a risk factor (OR: 1.4) for child wasting. Likewise, lack of access to improved water was also found as a risk factor (OR: 1.8). Access to household electricity was found as a very protective factor (OR: 0.3) for child wasting in one study.

Season, geographic location, and rural-urban residence factors (Table 5)

Seasonal variances were also observed in three studies, e.g. during post-Amon harvest season (January-April) (OR: 0.7) and post-Aus harvest season (September-December) child wasting rate was found to be reduced (OR: 0.7 and 0.8 respectively). However, during the Monsoon season (May-August) child wasting rate increased (OR: 1.5). In addition, flood exposure was found as a huge risk factor (OR: 25.1) for child wasting in one

study. The risk of child being wasted was found to be higher if the residence was in Barisal, Rajshahi, Chittagong, and Rangpur divisions. Living in the eastern region of Bangladesh was associated with higher risk (OR: 1.4). The odds of childhood wasting were observed high in urban slums (1.4) in one study, and rural areas (1.2 to 1.2) than urban non-slum areas in two studies.

DISCUSSION

The findings of this review revealed that several factors affect or are associated with the wasting status of U-5 children in Bangladesh. These include (but not limited to) child's birth size, birth order, age, breastfeeding practices and status, diseases and immunization status; siblings and family size; mother's nutritional status; mother's or parent's education; parent's smoking habit; income and socioeconomic status; dietary diversity during pregnancy and availability of food or food insecurity at the household; hygiene and WASH practices; season and residence of children in different government administrative division and geographical location, slum or rural areas.

Our review suggested that children having low birth weight (LBW) or smaller than average size at birth had a higher risk of being wasted, which fits with the findings from Nigeria,¹¹ Ethiopia,¹² and Ghana¹³ and other regions.^{3,14} LBW was found to be associated with a number of supplements involved in childhood development e.g. vitamin A, zinc, and iron.¹⁵ The observed association between birth weight and malnutrition is consistent with the findings of other studies.¹⁶⁻²² Since child malnutrition can be traced to the fetal period,²² favorable socio-demographic conditions during the postnatal period usually cannot fully compensate for this initial setback. Since lower birth size is a salient predictor of wasting, reducing the factors influencing this such as adequate maternal nutritional status and prenatal care, might lead to a reduction in the prevalence of wasting.³

Table 4. Socioeconomic risk or associated factors of child wasting

	Odds Ratio (95% CI), <i>p</i> -value	Reference (respectively)
Wealth index		
Poor (compared to better wealth index)	2.88 (1.22-6.77), <i>p</i> =0.015 1.38 (1.14-1.68), <i>p</i> <0.05 1.51 (1.06-2.14), <i>p</i> =0.019	Jubayer et al (2020) ¹⁸⁰ Rahman et al (2021) ¹⁶² Rahman et al (2020) ¹⁶⁶
Wealth index, middle (compared to poor)	0.82 (0.76-0.90), <i>p</i> <0.001 0.73 (0.57-0.92), <i>p</i> =0.008 0.65 (0.47-0.93), <i>p</i> =0.018	Talukder et al (2021) ¹⁶³ Hossain et al (2020) ¹⁶⁵ Raihan et al (2020) ²⁶
Wealth index, rich (compared to poor)	0.58 (0.40-0.94), <i>p</i> <0.001 0.74 (0.57-0.96), <i>p</i> =0.025	Talukder et al (2021) ¹⁶³ Hossain et al (2020) ¹⁶⁵
Lower socioeconomic status	2.64 (2.36-2.96), <i>p</i> <0.05	Chowdhury et al (2011) ¹⁷⁷
Middle socioeconomic status	1.77 (1.59-1.97), <i>p</i> <0.05	Chowdhury et al (2011) ¹⁷⁷
Father with a low-paid job	5.78 (2.54-13.16), <i>p</i> <0.001	Fuchs et al (2014) ⁶⁴
Father's occupation labourer compared to agriculture	0.78 (0.63-0.91), <i>p</i> <0.01	Fuchs et al (2014) ⁶⁴
Monthly family income < 10000 taka (1 US \$=80 taka)	2.87 (1.31-6.29), <i>p</i> =0.008	Fuchs et al (2014) ⁶⁴
Food insecurity		
Moderate food insecurity	1.66 (1.12-2.46), <i>p</i> =0.011	Choudhury et al (2017) ¹²⁸
Severe food insecurity	1.34 (1.09-1.63), <i>p</i> =0.005	Choudhury et al (2017) ¹²⁸
Latrine type		
Access to hygienic latrine	0.25 (0.07-0.82), <i>p</i> =0.022	Hoq et al (2019) ¹⁶⁷
Having non-hygienic latrine	1.36 (1.04-1.78), <i>p</i> =0.025	Choudhury et al (2017) ¹²⁸
Lack of improved water	1.78, <i>p</i> <0.05	Harding et al (2018) ⁸⁸
Access to household electricity	0.27 (0.09-0.81), <i>p</i> =0.02	Islam et al (2018) ⁸⁸

Table 5. Seasons, geographic location, and rural-urban residence-related risk or associated factors of child wasting

The risk or associated factors	Odds Ratio (95% CI), <i>p</i> -value	Reference (respectively)
Season		
Post-Amon harvest season (January-April)	0.74 (0.66-0.83), <i>p</i> <0.001	Mohsena et al (2018) ¹⁷²
Post-Aus harvest season (September-December)	0.76 (0.68-0.85), <i>p</i> <0.001	Mohsena et al (2018) ¹⁷²
Monsoon season	1.45 (1.15-1.84), <i>p</i> =0.002	Choudhury et al (2017) ¹²⁸
Flood exposure	25.06 (1.81-347.45), <i>p</i> <0.05	Goudet, et al (2011) ¹⁷⁸
Administrative division/area/region		
Barisal	1.56 (1.21-2.02), <i>p</i> <0.05 1.57 (1.16-2.11), <i>p</i> =0.003 1.36 (1.02-1.81), <i>p</i> <0.05	Rahman et al (2021) ¹⁶² Rahman et al (2020) ¹⁶⁶ Harding et al (2018) ⁸⁸
Chittagong	1.40 (1.11-1.77), <i>p</i> <0.05	Rahman et al (2021) ¹⁶²
Rajshahi	1.50 (1.16-1.93), <i>p</i> <0.05 0.68 (0.50-0.94), <i>p</i> =0.019 1.64 (1.22-2.19), <i>p</i> =0.001 1.42 (1.07-1.88), <i>p</i> <0.05	Rahman et al (2021) ¹⁶² Rahman et al (2021) ¹⁶² Chowdhury et al (2020) ¹⁶⁴ Rahman et al (2020) ¹⁶⁶ Harding et al (2018) ⁸⁸
Rangpur	1.31 (1.01-1.69), <i>p</i> <0.05	Rahman et al (2021) ¹⁶²
Mymensingh	0.59 (0.42-0.84), <i>p</i> =0.004	Hossain et al (2020) ¹⁶⁵
Living in the Eastern region of Bangladesh	1.37 (1.02-1.84), <i>p</i> =0.037	Choudhury et al (2016) ⁶⁶
Eastern Hills agro-ecological zone	0.83 (0.70-0.99), <i>p</i> <0.05	Mohsena et al (2018) ¹⁷²
City-corporation slum (compared to other city areas)	1.35 (1.04-1.45), <i>p</i> <0.001	Talukder et al (2021) ¹⁶³
Rural (compared to urban) residence	1.23 (1.01-1.50), <i>p</i> =0.035 1.24, <i>p</i> <0.05	Rahman et al (2020) ¹⁶⁶ Harding et al (2018) ⁸⁸

Our review found that sex of the child was an important indicator of wasting, and this finding is coherent with the previous studies conducted in Ethiopia,¹² Nigeria,¹¹ and India.²³ Boys were found 16-36% more likely to be wasted than girls in Afghanistan, Bangladesh, India, and Pakistan. This is contradictory to some early literature on child undernutrition in South Asia, whereby girls were more likely to be stunted or wasted than boys.^{24, 25} The higher prevalence of wasting among male children compared to female children as found in this study is consistent with previous study reports^{11, 26-29} as well as studies from Pakistan, Ghana, and Sub-Saharan Africa.³⁰⁻³³ Moreover, all Demographic and Health Surveys in Bangladesh, India, and Nepal since mid-1990s have documented that the prevalence of wasting is higher among boys than girls. The mechanisms that underlie this relationship are unclear and warrant further investigation. However, it is often argued that the vulnerability of male children reflects a natural process.³⁴ Epidemiological proof suggested that male children are biologically more vulnerable to morbidity as compared to girls.^{35, 36} Other possible reasons behind the lower wasting rate among female children than male children can be explained by some factors: a) discrimination against female children in the allocation of food and healthcare within the household is now not as common as it was.^{37, 38} b) with gender differences, female children cope better than male children with less sufficient amount of food.³⁸ Although traditionally male children receive more attention from parents in Bangladesh, this situation has been changing recently. The Government of Bangladesh has implemented policies and programs 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 fam-

ilies. Consequently, parents now value the intelligence of their female children. Therefore, female children now face less discrimination in attention, and have adequate food provision, care, and support.

As we found children aged 12-23 months were more likely to suffer from wasting than the younger age group, confirming similar findings that older age was significantly associated with moderate wasting in children.^{2, 39} Older age (compared to less than 12 months) as a risk or associated factor for acute malnutrition (wasting) and other forms of undernutrition was also found in Tamil Nadu, India,⁴⁰ and Uganda.⁴¹ Similar findings on wasting and undernutrition have been repeatedly documented by other studies.^{23, 32, 42, 43} This can be explained by the fact that majority of children in Bangladesh are breastfed exclusively or at least predominantly for 5 to 6 months postnatally and a good proportion of children continues breast milk for up to 12 months,⁴⁴ hence the signs of malnutrition appear later when inadequate complementary feeding practices impede the child's nutritional status and growth. However, the increased wasting rate observed in children older than 24 months age group was not observed in our review.

Our review further revealed that breastfeeding status has a significant effect on the wasting status of children. Children had a lower risk of wasting when mothers had better breastfeeding practices. This is expected as breast-milk supplies all the necessary nutrients and also protects against infections. It should be noted that good nutritional status of the mother can lead to better breastfeeding and helps the mother to recover faster from both physical and mental stress after pregnancy. Other studies also reported the association between breastfeeding practices and nutritional status.⁴⁵⁻⁴⁸ Early initiation of breastfeeding and continuation of breastfeeding confirmed the protective effect against childhood diarrheal morbidity, which emphasizes universal breastfeeding programs for reducing diarrhea-related morbidities in the first two years of life.^{45, 49} The

hygienic and nutritional risks associated with bottle feeding and artificial milk are well known,⁵⁰⁻⁵² and previous studies also found that breastfeeding had a significant and substantial impact on overall survival of undernourished children.^{53, 54}

Our findings on vaccination status and wasting concur with the findings from Papua New Guinea⁵⁵ where they also reported that children with compromised nutritional status were less likely to be fully vaccinated.

Acute morbid conditions are one of the immediate causes of acute malnutrition (wasting) in children.² Similar to our findings, studies in Ethiopia⁵⁶ and India⁵⁷ also found significant associations of wasting specially with diarrhea and respiratory illness. The relationship between wasting and diseases, explained by Ayana et al. (2015), as a decrease in appetite and in the absorption of nutrients from the intestine during illness, can lead to weight loss.⁵⁶ Wasting was more prevalent in the children who suffered from fever, which is also a result consistent with those of previous studies.^{11, 39, 56, 58, 59} Ayana et al. further demonstrated that febrile illness was positively associated with reduced food intake and increased loss of fluids, which might lead to acute childhood undernutrition (wasting).

Our review observed an association between childhood malnutrition and the presence of under-5 siblings in a household. Although difficult to explain, this might be related to childcare and proper feeding practices. Studies reported that educated women prefer to have fewer children and adopt family planning measures, which help improve the overall nutritional status of children.⁶⁰ The presence of many young siblings i.e. the occurrence of close birth intervals may have adverse effects on nutritional status due to early weaning from breastmilk. Family size has been documented as a risk factor for malnutrition in several studies in Ethiopia, Pakistan, India, and Malaysia.^{21, 56, 57, 61, 62} They explained that children receive less attention from their parents when there is more than one child in the family in the same age group. Studies conducted in Africa⁴¹ and India⁶³ also reported an association between child wasting and inappropriate feeding practice and other care practices.

A mother of good nutritional status is likely to have healthier babies.^{64, 65} Poor maternal nutritional status was found to be a significant predictor of childhood wasting. Therefore, ensuring a better maternal nutritional status is essential and should be included in the formulation of policies and in programs on prevention of child undernutrition. Several similar studies have illustrated that low maternal body mass index (BMI) is related to acute undernutrition in children.^{11, 12, 28, 39, 59, 66, 67} Das and Gulshan (2017)⁶⁷ found that the children of mothers with a BMI of <18.5 had 2.1 times higher risk of being wasted than those of mothers with BMI >25.5. Rayhan and Khan (2006)²⁸ estimated that the children of mothers with a BMI >18.5 were 40% less likely to be wasted than those of mothers with BMI <18.5. Chowdhury et al. (2016)⁶⁶ found similar results. After controlling for many relevant covariates, maternal MUAC < 23 cm was significantly correlated with wasting, stunting, and underweight status among children. These findings are consistent with results from other settings,⁶⁸⁻⁷¹ suggesting that maternal MUAC is a significant predictor of childhood malnutrition. The

relationship between low maternal BMI and child wasting may be mediated through poor birth outcomes.⁷² Undernourished mothers often deliver low-birth-weight (LBW) infants,⁷³ which is an attributable risk factor for increased childhood malnutrition, morbidity, and mortality. Breastfeeding adequacy may also be compromised^{74, 75} in maternal malnutrition and such mothers might have less energy to appropriately care for their children. Appropriate maternal BMI and weight gain during pregnancy are associated with positive fetal outcomes,⁷⁶ indicating optimal maternal nutrition status is associated with positive birth outcomes.^{76, 77} Assuming that current maternal BMI reflects maternal BMI status during pre-pregnancy, our findings indicate that the protective effect of a higher BMI on wasting among children is sustained over a long period, hence higher maternal BMI could protect children from becoming malnourished. Furthermore, mothers with a low BMI or who are undernourished may not be able to produce and provide sufficient amounts of breastmilk for their infants, which may be a critical factor that leads to acute malnourishment among children.²⁸

Our finding of an inverse association between maternal height and wasting among U-5 children echoes findings from others.^{78, 79} Pooled data from 54 low-income countries showed that for every one-centimeter increase in maternal height significantly reduced the risk of wasting (relative risk = 0.994; 95% CI: 0.993, 0.995) among U-5 children.⁷⁸ Similarly, another large national survey (NFHS, 2005-2006) in India reported that every one-centimeter increase in maternal height was inversely associated with U-5 wasting (RR = 0.989; 95% CI: 0.984, 0.994).⁷⁹ The findings from these studies also confirmed the intergenerational association between maternal stature and child undernutrition in Bangladesh.

Our review observed positive associations between increased maternal food consumption during pregnancy and adequate pregnancy weight gain with birth outcomes and subsequent growth and development; and an association between maternal nutrition during pregnancy and fetal growth. Similar findings were also documented in other literature.^{3, 80} Fetal growth retardation due to sub-optimal nutrient intake during pregnancy may lead to a low birth weight, which is a critical risk factor for delayed growth during the first two years of life.^{3, 81} Hence, increased maternal food consumption during pregnancy may protect younger children from moderate wasting. An analysis of the cost-effectiveness of interventions for maternal and child health outcomes in terms of cost per death averted showed that maintaining optimal nutrition during pregnancy was the most expensive intervention.⁸²

Different studies determined the association between the education of parents and the nutritional status of U-5 children.^{83, 84} Particularly, mother's education is an underlying factor for wasting among U-5 children as found in our review and also reported by other researchers.^{12, 17, 23, 85-88} Children born to mothers with no education were more exposed to being wasted than children of mothers having primary, secondary, or higher education. This is because an educated mother has a better understanding of the basic needs of her newborn baby, and also has a greater scope of learning about the child's health. This finding calls for greater attention of the government to

form policies to facilitate educational environments at the institutional level, particularly for girls. Educated mothers are expected to be more aware of the health, hygiene, and sanitation of their children and consequently can take better care of the children healthwise.⁸⁹

Multiple studies^{90, 91} suggested that maternal knowledge of nutrition and health is significantly associated with children's nutrition status. Maternal knowledge of diarrheal management can be viewed as a proxy indicator for knowledge on managing common ailments. This knowledge can help prevent or reduce the duration of diarrheal and other common illnesses in children, thereby reducing the incidence of infections, an important risk factor for wasting. That indicated that raising awareness of mothers on the management of diarrhea and other minor ailments could be a potentially useful major intervention to prevent wasting. The result of our review is supported by other studies, showing an association between parental education with improved nutritional status of children in India, Thailand, Peru, Ghana, and Brazil.^{23, 92-94} Studies have also indicated that high level of maternal education are associated with protective childcare behaviors such as vitamin A capsule supplementation, complete childhood immunizations, better sanitation, and use of iodized salt.⁹⁵ Higher education also provides women a higher level of autonomy, greater decision-making power in the family regarding health-related matters, and better use of modern health facilities which could lead to better health outcomes of children.^{96, 97} Besides, there is a consensus that higher education leads to higher income. Hence, increasing household earnings enables parents to invest more in health care services and proper food intake for their children.⁹⁸ A possible reason behind this might be that educated mothers are usually more empowered and thus they make substantial decisions on dietary diversity and child health.⁹⁹ To empower women to make decisions on their own and their children's health, it is mandatory to educate them.¹⁰⁰ Besides, keeping girls in schools longer can delay the age of marriage and age of first birth, which might be a suitable way to empower them.^{101, 102} Previous research^{28, 103} found that primary education of mothers reduced the risk of childhood stunting, underweight, and wasting in U-5 children in Bangladesh. This finding was consistent with that of,¹⁰⁴ which showed that higher level of maternal education significantly reduced the odds of malnutrition in U-5 children in Malawi, Tanzania, and Zimbabwe and that a lower level of education had no impact. This pattern of prevalence was also reported in previous research.^{28, 105}

Similar to our findings, a study in Indonesia also detected an association between paternal smoking and an increased risk of child malnutrition.¹⁰⁶ Several studies in different parts of the world including Bangladesh revealed that money spent on smoking is potentially money not spent on food and deprives the family from their basic needs.¹⁰⁷⁻¹¹⁰ If the lower-income group could reallocate their smoking expenditure on food, there may be a considerable benefit on improved child nutrition, as well as child health.

Our review observed that children from families with lower income have a higher chance of acute undernutrition than children from middle-and-upper income fami-

lies. Similar findings were reported in other studies.^{2, 111, 112} Income insecurity leads to food insecurity, forcing family members to consume foods that are poor in both quality and quantity. Studies conducted in Bangladesh and India also observed that lower family income is a risk factor for childhood acute malnutrition.^{40, 113} Children coming from families with higher income and capital tend to have better diets with higher nutritional conditions, leading to lower odds of having wasted children.¹¹⁴ The wealth index was negatively associated with wasting. Women from wealthy families have a better/greater intake of nutrients and their children have better nutritional status, whereas poor families are unlikely to manage the cost and remain undernourished.¹¹⁵ Previous research found that the odds of being wasted are higher among children of poor families than those of rich families.^{17, 23, 27, 59, 72, 87} Lower economic status is related to some issues closely linked to the wealth index that would increase acute undernutrition among U-5 children as inadequacy of wealth means inadequacy of basic amenities, such as education, health services, food, and shelter.⁸⁷ Diseases such as fever and diarrhea frequently occur in poor families and lead to childhood undernutrition.^{87, 116} Ortiz et al. (2013) and Musa et al. (2017) have mentioned that poor access to health services can be related to acute undernutrition.^{116, 117} Household wealth has been widely referenced as a determinant of wasting.¹¹⁴

This review identified lack of dietary diversity as one of the key problems of childhood wasting. Previous surveys have reported that households consume low-quality diets with little diversity because they lack the resources to grow or purchase micronutrient-rich foods.¹¹⁸ The findings of this review support existing literature on the association of child undernutrition with less maternal food consumption during pregnancy.¹¹⁹ In the context of maternal characteristics causing wasting in children, the amount and diversity of food consumed during pregnancy has been found as a contributing factor to both maternal and child health and nutritional status.¹²⁰ In most of the reviewed articles, the data collection was based on cross-sectional design, we assumed that current maternal dietary diversity would reflect the dietary diversity during her last pregnancy. However, socioeconomic status also demonstrated significant role for ensuring dietary diversity and the wealthier quintiles had better access and afford the minimal acceptable diet (MAD) (who consumed ≥ 4 food groups in the 24 h) than those who are poorest.¹²¹ It is evident that poor people also do not use the advantages of health-care services if their particular health problem is not severe as they do not have proper financial security.¹²² The effect of food insecurity remained strong even after controlling for common and significant socioeconomic characteristics. Therefore, intervention should be taken to eradicate food insecurity. A comprehensive National Food Policy developed in Bangladesh in 2008 was followed in 2011 by the Country Investment Plan, which provided stakeholders with a clear roadmap for investment in agriculture, food security and nutrition.¹²³ Low dietary intake of micronutrients has negative consequences for children's growth. Nutritional practice of children is hampered by various causes, such as poverty, lack of parental education, especially maternal education, ine-

qualities in urban-rural place of residence, underutilization of health service, poor quality care, and environment.^{103, 124-126} Severely food insecure children also led to the higher prevalence of stunting, wasting, and underweight.¹²⁷ The significant association between household food insecurity and malnutrition in children was also reported.^{128, 129} Moreover, the proportion of children receiving MAD (consumed ≥ 4 food groups in the 24 h preceding the survey) and the proportion of food secure households were both lower than the national figures;⁶ thus, there malnutrition could be alleviated by improving MAD and food security status. Previous literature found that children's nutrition status is associated with food availability in the household.¹²⁸ MDD is significantly associated with the child nutritional status which reduces the risk of stunting, wasting, and underweight,^{130, 131} as the variety and quantity of food items reflects an increase of micro-nutrients intake.

Unhealthy household environment was found as an underlying cause of acute malnutrition (wasting).² The relationship with hygienic latrine and control of waterborne diseases, such as diarrhea, is well established. The authors also reported significant decrease in under 2 child malnutrition over time in the intervention area with better coverage of hygienic latrine compared with only health intervention area.¹³² A study conducted in Ethiopia also found that malnutrition was associated to latrine access.⁵⁶ In general, several studies that were carried out in developing communities suggest an association between childhood diarrhea and poor hygiene and WASH conditions.¹³³⁻¹³⁵ Diarrhea causes lower appetite and often affect the absorption of nutrients.¹³⁶ Likewise, undernutrition may prolong the duration and frequency of diarrhea as well as worsen the overall health condition of the child.¹³⁷ Diarrhea may also have an indirect contribution to undernutrition through the costs of medication that households spend in treatment, which may affect their food budget.¹³⁸ Overall, limited water access, and poor hygiene and sanitation can lead to diarrhea, which can lead to undernutrition. Similar to one of our findings, other studies also reported access for electricity connection and refrigeration for storing perishable food items may lead to an increase consumption of nutritious foods. The relationship between childhood undernutrition/wasting with refrigerator ownership and increased dietary diversity and reduced food insecurity has been established in the literature.^{139, 140}

Seasonality is closely related to domestic crop production, which aligns with the significant association between the post-harvest and monsoon seasons and various categories of undernutrition, including wasting in children. Like us, other studies have found that children are more likely to have poorer nutritional status in the dry season compared to the wet season.¹⁴¹ Also, due to the difference in harvesting period of staples, Bangladesh traditionally suffers a loss in rice production during monsoon, which translates to an increase in child wasting especially in the rural communities.¹⁴²

Also, similar to our findings, other studies found a significant regional differences in terms of prevalence of malnutrition.^{111, 143} Malnutrition may conceal important intraregional differences due to diverse cultural norms

that might affect nutritional practice. Wide regional variations within countries have also been reported by other studies.^{144, 145} An earlier study in India found an increasing prevalence of child malnourishment in certain spatial areas, described as 'pockets of concentration' of malnourishment.¹⁴⁶ Even in countries like the United States and Malaysia, malnutrition-prevalent regions still exist, most of which are populated by ethnic minorities and spatially distanced from the major urban centers.¹⁴⁷ Thus, it is not surprising that similar pockets exist in Bangladesh, where the Haor (a bowl- or saucer-shaped tectonic depression that is submerged with run-off rainwater from upstream) areas are geographically distinct from other areas. Findings of the present study suggest that policymakers need to turn their heads to the Haor Basin area to decrease inter-regional disparity.

The place of residence was also found to be a significant risk factor in U-5 children wasting in other studies.^{148, 149} Our review also revealed that the prevalence of wasting in slum areas was higher than non-slum areas. The possible reason is that most people in slum areas are illiterate and poor. No or less education makes them less aware about the nutritional condition of their children, and lack of wealth leads to them not able to provide adequate nutritious food for their U-5 children. Living in poorer rural conditions with inadequate food intake, lack of fundamental health services and greater risk to infections can lead to rural children being more prone to wasting and stunting than those in urban areas and live in better-off households. This result supported the findings from earlier research in other developing countries^{23, 31, 150, 151} and further confirmed that household economic condition is a key component of nutritional status of children under two years in developing countries. In developing countries, rural-urban inequality in child malnutrition remained unchanged over the last decades due to economic hardship, inadequate health facilities, and insufficient education.^{67, 152, 153} Rural children had a higher risk of wasting 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 with those of previous studies,^{11, 27} where the population most vulnerable were rural households severely affected by difficulties related to poverty and health. Therefore, income-generating activities and awareness building interventions in rural areas may improve the nutritional status of the children in these areas.¹⁵⁴

Strengths and limitations

This review has several strengths and limitations. The main strength of this study is that the data of different studies were of national level in Bangladesh. Given this, the findings will help the policy makers within the country to formulate appropriate national-level policies and programs to reduce wasting among U-5 children. However, the review has its limitations. Most reviewed papers, articles and reports were from cross-sectional study. Causality cannot be inferred due to the cross-sectional nature of this study; hence, only association between variables were reported. Most of the reviewed papers, articles and

reports analyzed cases have acute malnutrition defined by the WLZ-score cut-off value. Inclusion of acutely malnourished cases defined by MUAC cut-off value was only in few studies. Inclusion of wasting status by MUAC in all studies gave us the opportunity to analyze the full spectrum of cases that can be considered as moderate or severe wasting. One of the possible limitations may be interviewer bias, whereby in most studies, the personnel who obtained the anthropometric measurements of the children and mothers also conducted the interviews. However, most of the variables identified as risk or associated factors for acute malnutrition in our study were objective. Finally, information (especially the morbidity data) collected through maternal responses may be prone to recall bias. Nonetheless, the systematic sampling and robust sample size ensured that potential recall bias is diluted. Despite all of these, the findings can be generalized at the country level because data were mostly from nationally representative household surveys.

Conclusion and recommendation

These review-findings shed light upon some possible policy responses in dealing with wasting among U-5 children in Bangladesh and similar countries. Many of the underlying determinants of wasting have become the primary focus of nutrition programming in recent years for prevention. As suggested by World Health Organization (WHO), targeted actions against wasting is not only vital but also cost effective.¹⁵⁵ Emphasis has appropriately come to be placed on the first 1,000 days, that is, the period from conception through two years of life, as the critical window of opportunity where substantial impacts can be achieved on child physical growth and brain development.^{3, 156, 157}

The Government of Bangladesh has prioritized and implemented nutrition specific interventions including supporting infant and young child feeding (IYCF), micronutrient supplementation, food fortification and other health interventions e.g. antenatal care services which should be strengthened and continued ensuring quality and equity. In addition, community awareness activities should also be strengthened to improve awareness on appropriate IYCF practices, maternal and adolescent nutrition and health knowledge and attitudes towards health care, health and reproductive behaviors. Curative services, such as: early detection of wasted children (especially by MUAC screening) with special attention to hard-to-reach parts of the country, such as the Chittagong Hill Tracts, tea gardens, haor or flood plains, urban slums, and Forcibly Displaced Myanmar Nationals etc.; referral to stabilization centers for the children suffering from severe wasting or severe acute malnutrition; establishment of community based management of acute malnutrition (CMAM); inclusion of rotaviral vaccine in the National EPI program, etc. should be started or strengthened as early as possible. The World Bank recently estimated that every US\$ 1 invested in the treatment of severe wasting brings US\$ 4 in economic benefits.¹⁵⁸

Nutrition-sensitive interventions which include access to safe water, sanitation, women's education, gender equality, female autonomy and empowerment, nutrition sensitive social safety net programs and the availability of

diversified nutrient rich safe food— are key drivers of reductions in children's wasting and other forms of undernutrition. Interventions to improve education and household income-generating activities among poor households to reduce inequalities, in addition to targeted nutrition care of the mother and child, should be supported further as stated in the national policy agenda.

Interventions to increase coverage and access to hygienic latrines need to be intensified by the local government and the non-governmental organizations.

The causal framework of acute malnutrition is complex and needs multi-sectoral preventive interventions to improve nutrition status of children. The findings of this systematic review suggest that long-term above mentioned relevant, doable and sustainable strategies/programs with the combined efforts of government and non-governmental organizations for tackling malnutrition in U-5 children in Bangladesh must be considered and continued. Further reductions in child wasting and other forms of undernutrition require an increase of investment, improved coordination between relevant sectors and strengthened monitoring.

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CONFLICT OF INTEREST AND FUNDING DISCLOSURE

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