Urban-rural Differences in the Risk Factors of Severe Under-5 Child Malnutrition in Bangladesh

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Abstract

Introduction

Severe under-5 child malnutrition (i.e., severe stunting, severe wasting and severe underweight) is high in Bangladesh. The interplay between risk factors needs to be understood to address this complex public health issues. We aim to explore the prevalence and risk factors for severe under-5 child malnutrition in Bangladesh's rural and urban areas using the Composite Index of Severe Anthropometric Failure (CISAF).

Methods

We analysed data from Bangladesh Demographic Health Surveys (BDHSs), 2017-18. Severe malnutrition was defined using the CISAF, and conventional nutritional indicators were aggregated to estimate malnutrition's overall burden. The proportional differences of variables between non-severe malnutrition and severe malnutrition group were assessed using Chi-square test. Risk factors for malnutrition were analysed using regression models to assess the odds ratio (OR) and 95% confidence interval (CI).

Results

The overall prevalence of severe under-5 child malnutrition was 11% with 12% in rural areas and 10% in urban areas. The key risk factors in rural areas were children born with small birth weight (OR: 2.4, 95% CI: 1.5–3.8), socio-economically poorest households (OR: 2.3, 95% CI: 1.4–3.7) and children aged 36-47 months (OR: 2.1, 95% CI: 1.6–2.8). The key risk factors in urban areas were children born with small birth weight (OR: 5.0, 95% CI: 2.9–8.6), children of mothers with no formal education (OR: 2.0, 95% CI: 1.2–3.6) and children's birth order ≥4 (OR: 1.8, 95% CI: 1.2–2.8). 52% lower risk difference of parents with formal education vs no formal education, and 71% higher risk difference of most affluent vs poorest household for being severely malnourished were estimated in rural areas than in urban areas.

Conclusion

One in ten children living in both rural and urban areas experience severe malnutrition. Children of parents with no formal education, children of underweight mothers, those living in socio-economically poorest households and children of small birth weight experienced severe malnutrition regardless of setting. Educational attainments and access to health and nutritional care may not be enough to reduce the burden of severe malnutrition in rural settings. Our study provides helpful guidelines for context-specific interventions to reduce under-5 severe malnutrition.

Introduction

Malnutrition is the most common nutritional disorder in developing countries [1]. Over 40% of Bangladeshi children under-5 experience malnutrition, with 18% experiencing severe malnutrition [2]. Globally, around 195 million children under-5 suffer from some form of malnutrition [3]. Poor physical

growth, morbidity, inadequate cognitive development, and physical incapacity are directly related to malnutrition severity [4]. Further, approximately 3 million children under-5 die from malnutrition [5].

Risk factors for malnutrition are shaped by people's complex interactions with their social, cultural, economic, and environmental contexts. Social determinants of health provide a framework for understanding the inequalities in health risks and outcomes within and between populations [6]. Low maternal education, low-socioeconomic status (SES), low-income households, low birth weight, inadequate infant and young child feeding practices, frequent infections, inadequate access to health care, unsafe drinking water and lack of access to sanitation are some of the established risk factors [2,3,7,8]. However, current evidence on severe under-5 child malnutrition focused on single indicators/conventional indicators (i.e. severe stunting, severe wasting and/or severe underweight) and economic dimensions at single time points. These conventional indicators partly overlap, thus does not provide a comprehensive estimate of the proportion of malnourished children in the population.

The Composite Index of Anthropometric Failure (CIAF) uses conventional nutritional indicators to provide six different malnutrition measurements. The overall burden of malnutrition was estimated by aggregating conventional nutritional indicators' values [9]. The CIAF, therefore, accurately estimate the proportion of malnourished children in the population. [9]. The Composite Index of Severe Anthropometric Failure (CISAF) is an updated version of the CIAF that provides a comprehensive view of the extent and pattern of risk factors of severe malnutrition in resource-poor settings [10]. However, no previous study used CISAF to explore the prevalence and complex interplay between individual, community, public policy and environment level risk factors of severe under-5 child malnutrition in Bangladesh. Therefore, we aim to explore the prevalence and risk factors for severe under-5 child malnutrition in Bangladesh's rural and urban areas using the CISAF.

Methodology

We analysed data from the 2017-18 wave of the Bangladesh Demographic Health Survey (BDHS). The average response rate was 99%. The BDHS use two-stage stratified sampling techniques to select primary sampling units (PSUs) and households. During the first stage, PSUs or enumeration areas (EA) were designed based on the census survey 2011 conducted by the Bangladesh Bureau of Statistics. The probability proportional to EA size technique was used to select PSUs. During the second stage, an equal probability systematic sampling technique was used to select households from PSUs. The BDHSs collect data on social and demographic factors, health and nutritional factors from adults (male and female) residing in non-institutional dwellings. A standard questionnaire was used for data collection. For details of the survey questionnaire, sample design, data collection procedure (see BDHS reports 2017-18) [11]. The 2017-18 wave collected anthropometric data from 8,759 under-5 children, and data from 7,661 children were analysed (Fig. 1).

Outcome variables

Severe nutritional indicators for under-5 children were categorised into seven groups: (A) no severe failure; (B) severe wasting only; (C) severe wasting and severe underweight; (D) severe wasting, severe stunting and severe underweight; (E) severe stunting and severe underweight; (F) severe stunting only; and (Y) severe underweight only (Table 1). A child is considered severely malnourished if she/he has any anthropometric failure from B to Y (Fig. 2).

Table 1
Classification of children with severe anthropometric failure

Group name	Description	Severe Wasting	Severe Stunting	Severe Underweight
A	No severe failure	No	No	No
B	Severe wasting only	Yes	No	No
C	Severe wasting and severe underweight	Yes	No	Yes
D	Severe wasting, severe stunting and severe underweight	Yes	Yes	Yes
E	Severe stunting and severe underweight	No	Yes	Yes
F	Severe stunting only	No	Yes	No
Y	Severe underweight only	No	No	Yes

The primary outcome measure was severe under-5 child malnutrition using the CISAF. A child was considered to be severely stunted, severely wasted and severely underweight if the height-for-age, weight-for-height, and weight-for-age indices were three Standard Deviations (SDs) or more below the respective median of the World Health Organization (WHO) reference population [12].

Independent variables

Independent variables were selected based on the previously identified risk factors [2,3,13,14,15]. These variables include maternal age in years (15–19, 20–24, 25–29, 30–34, 35–39, ≥ 40); parents' education (both parents with no formal education, only father was with no formal education when mother was educated, only mother was with no formal education when father was educated, both parents educated); mother's current working status (currently not working, currently working); mother's nutritional status (normal/average, underweight); status of mother's antenatal and postnatal care (not received, received); mother's experience of inmate partner violence (IPV) (not experienced, experienced: a wife being beaten by partner if she went out without telling him or/and neglected the children or/and she ever argued with her partner or/and burned food or/and refused to have sex) [11]; decision-making autonomy (not experienced, experienced: a woman who usually decides by herself/jointly with husband at least on her healthcare or on large household purchases or visits to family or relatives) [11]; religion (Islam, others); source of drinking water (improved, unimproved) [16], use of solid waste in cooking (solid, non-solid); type

of toilet facility (improved, unimproved) [16], mass media exposure (no, yes: exposure to either radio, television, newspapers, or magazines at least once a week), wealth index (integrating household asset ownership and access to drinking water and sanitation) [11]. Moreover, factors related to children, e.g. age, birth order, and birth weight status [17,18,19] recent morbidity status (child had at least one morbid condition out of diarrhea, fever and cough in the two weeks preceding the survey) [11] were included.

Statistical analysis

Socio-demographic characteristics were analysed using descriptive statistics. The proportional differences of variables between non-severe malnutrition and severe malnutrition group were assessed using the Chi-square test. The significance level was set at $P < 0.05$ (2-tailed). Both unadjusted and adjusted models were developed using logistic regression to analyse risk factors of malnutrition measured by CISAF. All independent variables found significant in bivariate analysis were simultaneously entered into the multiple regression models for adjustment to assess odds ratio (OR) and confidence interval (CI). All statistical analyses were performed in Stata version 14.2 (StataCorp LP, College Station, Texas).

Results

Of the 7,661 under-5 children, 66% lived in rural areas. Most mothers (75%) were < 30 years old. People who lived in rural areas were socio-economically poor (54% rural vs 19% urban), and more mothers were underweight (16% rural vs 12% urban). 4% of parents who lived in rural areas and 3% of parents who lived in rural areas were with no formal education. Access to mass media was high in urban areas (56% rural vs 79% urban). (Table 2).

Table 2
Background characteristics of the children

Characteristics	Total (%)	Rural (%)	Urban (%)
Maternal age (years)			
15–19	938 (12.2)	657 (13.0)	281 (10.8)
20–24	2,679 (35.0)	1,818 (36.0)	861 (33.0)
25–29	2,146 (28.0)	1,395 (27.6)	751 (28.8)
30–34	1,293 (16.9)	825 (16.3)	468 (18.0)
34–39	481 (6.3)	291 (5.8)	190 (7.3)
≥ 40	124 (1.6)	70 (1.4)	54 (2.1)
Parents' education			
Both parents with no formal education	294 (3.8)	208 (4.1)	86 (3.3)
Only father with no formal education	865 (11.3)	654 (12.9)	211 (8.1)
Only mother with no formal education	243 (3.2)	154 (3.1)	89 (3.4)
Both parents with formal education	6,259 (81.7)	4,040 (79.9)	2,219 (85.2)
Mother currently working			
No	4,560 (59.5)	2,788 (55.1)	1,772 (68.0)
Yes	3,101 (40.5)	2,268 (44.9)	833 (32.0)
Underweight mother (< 18.5 kg/m^2)			
No	6,535 (85.3)	4,246 (84.0)	2,289 (87.9)
Yes	1,126 (14.7)	810 (16.0)	316 (12.1)
Mothers received antenatal care (n = 4,540)			
No	363 (8.0)	285 (9.5)	78 (5.1)
Yes	4,177 (92.0)	2,727 (90.5)	1,450 (94.9)

[a]defined as women's decision making power relative to their male partners

[b]integrating household asset ownership and access to drinking water and sanitation

[c]child's size and weight at birth based on a mother's perception

[d] child had at least one morbid condition out of diarrhea, fever and cough in the two weeks preceding the survey.

Characteristics	Total (%)	Rural (%)	Urban (%)
Mothers received postnatal care (n = 4,535)			
No	1,509 (33.3)	970 (32.2)	539 (35.4)
Yes	3,026 (66.7)	2,041 (67.8)	985 (64.6)
Mothers experience IPV			
No	6,274 (81.9)	4,042 (79.9)	2,232 (85.7)
Yes	1,387 (18.1)	1,014 (20.1)	373 (14.3)
Mothers' decision-making autonomy[a]			
Not practiced	1,083 (14.1)	786 (15.5)	297 (11.4)
Practiced	6,578 (85.9)	4,270 (84.5)	2,308 (71.9)
Religion			
Islam	6,997 (91.3)	4,608 (91.1)	2,389 (91.7)
Others	664 (8.7)	448 (8.9)	216 (8.3)
Source of water			
Improved	6,658 (86.9)	4,332 (85.7)	2,326 (89.3)
Unimproved	1,003 (13.1)	724 (14.3)	279 (10.7)
Solid waste use in cooking			
No	2,218 (29.0)	899 (17.8)	1,319 (50.6)
Yes	5,443 (71.0)	4,157 (82.2)	1,286 (49.4)
Type of toilet facility			
Improved	4,359 (56.9)	2,638 (52.2)	1,721 (66.1)
Unimproved	3,302 (43.1)	2,418 (47.8)	884 (33.9)
Mass media exposure			
No	2,771 (36.1)	2,232 (44.2)	539 (20.7)

[a]defined as women's decision making power relative to their male partners

[b]integrating household asset ownership and access to drinking water and sanitation

[c]child's size and weight at birth based on a mother's perception

[d] child had at least one morbid condition out of diarrhea, fever and cough in the two weeks preceding the survey.

Characteristics	Total (%)	Rural (%)	Urban (%)
Yes	4,890 (63.8)	2,824 (55.8)	2,066 (79.3)
Wealth index[b]			
Poorest	1,708 (22.3)	1,422 (28.1)	286 (11.0)
Poorer	1,545 (20.2)	1,325 (26.2)	220 (8.4)
Middle	1,381 (18.0)	1,024 (20.2)	357 (13.7)
Richer	1,533 (20.0)	827 (16.4)	706 (27.1)
Richest	1,494 (19.5)	458 (9.1)	1,036 (39.8)
Children age			
0–11 months	1,673 (21.8)	1,120 (22.2)	553 (21.2)
12–23 months	1,583 (20.7)	1,058 (20.9)	525 (20.1)
24–35 months	1,475 (19.3)	973 (19.2)	502 (19.3)
36–47 months	1,417 (18.5)	939 (18.6)	478 (18.4)
48–59 months	1,513 (19.7)	966 (19.1)	547 (21.0)
Sex of child			
Male	3,995 (51.2)	2,673 (52.9)	1,322 (50.7)
Female	3,666 (47.8)	2,383 (47.1)	1,283 (49.3)
Birth order			
First	2,902 (37.9)	1,848 (36.6)	1,054 (40.4)
Second	2,507 (32.7)	1,617 (32.0)	890 (34.2)
Third	1,297 (16.9)	893 (17.7)	404 (15.5)
Fourth and above	955 (12.5)	698 (13.8)	257 (9.9)
Small birth weight[c] (n = 4,735)			

[a]defined as women's decision making power relative to their male partners

[b]integrating household asset ownership and access to drinking water and sanitation

[c]child's size and weight at birth based on a mother's perception

[d] child had at least one morbid condition out of diarrhea, fever and cough in the two weeks preceding the survey.

Characteristics	Total (%)	Rural (%)	Urban (%)
No	1,815 (38.3)	1,036 (32.9)	779 (49.2)
Yes	326 (6.9)	190 (6.0)	136 (8.6)
Not weighted	2,594 (54.8)	1,927 (61.1)	667 (42.2)
Recent morbidity status[d]			
No	4,043 (52.8)	2,636 (52.1)	1,407 (54.0)
Yes	3,618 (47.2)	2,420 (47.9)	1,198 (46.0)
Total	7,661 (100.0)	5,056 (66.0)	2,605 (34.0)

[a]defined as women's decision making power relative to their male partners

[b]integrating household asset ownership and access to drinking water and sanitation

[c]child's size and weight at birth based on a mother's perception

[d] child had at least one morbid condition out of diarrhea, fever and cough in the two weeks preceding the survey.

Prevalence of under-5 severe malnutrition

The prevalence of under-5 severe malnutrition measured by CISAF was 11.0% for all of Bangladesh (12% rural vs 10% urban) (Table 3). The overall prevalence of severe stunting, severe wasting and severe underweight was 9%, 1% and 4%, respectively. The prevalence of severe stunting, severe wasting and severe underweight in urban areas was 8%, 1% and 4% respectively and 9%, 1% and 5% respectively in rural areas (Fig. 2). Sylhet region reported the highest prevalence of severe under-5 child malnutrition (17% rural vs 13% urban) (Fig. 3).

Table 3
Prevalence of under-5 child undernutrition in urban-rural context

Characteristics	Rural		Urban	
	Number	Prevalence (95% CI)	Number	Prevalence (95% CI)
Maternal age (years)				
15–19	85	11.5 (9.2, 14.2)	36	13.2 (8.9, 19.1)
20–24	201	10.5 (8.9, 12.3)	77	9.5 (6.9, 12.9)
25–29	176	12.3 (10.4, 14.5)	68	7.9 (6.0, 10.4)
30–34	103	12.4 (9.9, 15.5)	41	8.6 (5.8, 12.6)
34–39	35	11.0 (7.9, 15.1)	84	13.9 (8.8, 21.1)
≥ 40	9	11.8 (6.1, 21.7)	7	9.8 (3.8, 23.1)
	χ^2 = 3.58, p = 0.669		χ^2 = 11.09, p = 0.186	
Parents' education				
Both parents with no formal education	42	21.5 (15.7, 28.8)	23	25.9 (17.2, 36.9)
Only father with no formal education	113	16.9 (13.7, 20.5)	28	13.9 (9.0, 21.0)
Only mother with no formal education	35	21.8 (15.5, 29.6)	11	12.0 (6.1, 22.1)
Both parents with formal education	419	9.8 (11.3, 14.9)	194	8.4 (6.9, 10.2)
	χ^2 = 64.76, p = < 0.001		χ^2 = 37.89, p < 0.001	
Mother currently working				
No	321	10.7 (9.2, 12.3)	166	8.8 (7.1, 10.8)
Yes	288	12.6 (11.1, 14.2)	90	11.4 (8.9, 14.6)
	χ^2 = 4.40, p = 0.080		χ^2 = 4.52, p = 0.060	

[a]defined as women's decision making power relative to their male partners

[b]exposure to either radio, television, newspapers, or magazines at least once a week

[c]integrating household asset ownership and access to drinking water and sanitation

[d]child's size and weight at birth based on a mother's perception

[e]child had at least one morbid condition out of diarrhea, fever and cough in the two weeks preceding the survey.

Characteristics	Rural		Urban	
	Number	Prevalence (95% CI)	Number	Prevalence (95% CI)
Underweight mother				
No	468	10.5 (9.4, 11.8)	201	8.9 (7.3, 10.7)
Yes	141	17.1 (14.4, 20.2)	55	15.4 (11.1, 21.0)
	χ^2 = 26.99, $p < 0.001$		χ^2 = 12.99, $p = 0.001$	
Mothers received antenatal care				
No	49	17.8 (13.1, 23.8)	17	20.9 (11.8, 34.3)
Yes	325	11.2 (9.9, 12.5)	147	9.9 (8.1, 12.0)
	χ^2 = 10.35, $p = 0.003$		χ^2 = 10.12, $p = 0.012$	
Mothers received postnatal care				
No	92	9.5 (7.6, 11.9)	40	5.9 (4.0, 8.8)
Yes	282	12.9 (11.4, 14.6)	123	13.1 (10.3, 16.5)
	χ^2 = 7.30, $p = 0.015$		χ^2 = 19.57, $p = 0.001$	
Mothers experience IPV				
No	458	10.9 (9.7, 12.2)	220	9.7 (8.0, 11.7)
Yes	151	13.9 (11.5, 16.6)	36	9.1 (5.8, 14.0)
	χ^2 = 7.10, $p = 0.020$		χ^2 = 0.14, $p = 0.775$	
Mother's decision-making autonomy[a]				
No	96	11.3 (9.2, 13.8)	36	11.0 (7.8, 15.3)
Yes	513	11.5 (10.3, 12.9)	220	9.4 (7.7, 11.4)

[a]defined as women's decision making power relative to their male partners

[b]exposure to either radio, television, newspapers, or magazines at least once a week

[c]integrating household asset ownership and access to drinking water and sanitation

[d]child's size and weight at birth based on a mother's perception

[e]child had at least one morbid condition out of diarrhea, fever and cough in the two weeks preceding the survey.

Characteristics	Rural		Urban	
	Number	Prevalence (95% CI)	Number	Prevalence (95% CI)
	χ^2 = 0.03, p = 0.865		χ^2 = 0.78, p = 0.390	
Religion				
Islam	557	11.5 (10.4, 12.8)	236	9.7 (8.0, 11.7)
Others	52	11.0 (8.5, 14.2)	20	8.5 (4.6, 15.1)
	χ^2 = 0.12, p = 0.726		χ^2 = 0.28, p = 0.676	
Source of drinking water				
Improved	532	11.8 (10.6, 13.1)	229	9.6 (8.0, 11.6)
Unimproved	77	9.6 (7.5, 12.1)	27	9.3 (15.0, 20.7)
	χ^2 = 3.03, p = 0.102		χ^2 = 0.03, p = 0.862	
Solid waste use in cooking				
No	82	8.6 (6.6, 11.1)	95	7.9 (6.2, 10.1)
Yes	527	12.2 (10.9, 13.5)	161	12.1 (9.7, 15.1)
	χ^2 = 9.98, p = 0.011		χ^2 = 12.99, p = 0.005	
Type of toilet facility				
Improved	272	10.2 (8.8, 11.7)	146	8.4 (6.8, 10.5)
Unimproved	337	13.0 (11.5, 14.6)	110	12.0 (8.9, 16.0)
	χ^2 = 9.73, p = 0.004		χ^2 = 8.35, p = 0.057	
Mass media exposure[b]				
No	328	14.6 (12.7, 16.7)	82	15.4 (10.8, 21.4)

[a]defined as women's decision making power relative to their male partners

[b]exposure to either radio, television, newspapers, or magazines at least once a week

[c]integrating household asset ownership and access to drinking water and sanitation

[d]child's size and weight at birth based on a mother's perception

[e]child had at least one morbid condition out of diarrhea, fever and cough in the two weeks preceding the survey.

Characteristics	Rural		Urban	
	Number	Prevalence (95% CI)	Number	Prevalence (95% CI)
Yes	281	9.3 (8.2, 10.7)	174	8.3 (7.0, 9.8)
	χ^2 = 33.16, p < 0.001		χ^2 = 23.01, p = 0.0008	
Wealth index[c]				
Poorest	234	16.1 (14.0, 18.4)	50	18.7 (11.7, 28.7)
Poorer	178	12.8 (10.9, 15.1)	40	16.1 (11.6, 22.1)
Middle	98	9.2 (7.3, 11.6)	41	10.6 (7.2, 15.4)
Richer	75	8.9 (6.8, 11.6)	63	9.7 (7.1, 13.1)
Richest	24	5.0 (3.1, 8.1)	62	6.4 (4.9, 8.3)
	χ^2 = 60.34, p < 0.001		χ^2 = 44.82, p = < 0.001	
Children age				
0–11 months	95	8.1 (6.6, 10.0)	53	7.5 (5.0, 11.0)
12–23 months	153	13.4 (11.3, 15.8)	56	10.4 (7.6, 14.1)
24–35 months	155	15.2 (12.8, 17.9)	62	14.2 (10.8, 18.6)
36–47 months	102	10.8 (8.6, 13.5)	41	8.2 (5.6, 12.0)
48–59 months	104	10.1 (8.1, 12.6)	44	7.9 (5.5, 11.3)
	χ^2 = 31.49, p < 0.001		χ^2 = 18.48, p = 0.013	
Sex of child				
Male	326	11.4 (10.1, 12.9)	137	10.5 (8.5, 12.8)
Female	283	11.6 (10.0, 13.4)	119	8.7 (6.8, 11.1)

[a]defined as women's decision making power relative to their male partners

[b]exposure to either radio, television, newspapers, or magazines at least once a week

[c]integrating household asset ownership and access to drinking water and sanitation

[d]child's size and weight at birth based on a mother's perception

[e]child had at least one morbid condition out of diarrhea, fever and cough in the two weeks preceding the survey.

Characteristics	Rural		Urban	
	Number	Prevalence (95% CI)	Number	Prevalence (95% CI)
	χ^2 = 0.03, p = 0.871		χ^2 = 2.29, p = 0.159	
Birth order				
First	197	10.1 (8.6, 11.8)	84	8.3 (6.4, 10.9)
Second	184	10.7 (9.1, 12.4)	83	8.7 (6.5, 11.7)
Third	114	12.3 (10.1, 14.8)	41	9.3 (6.5, 13.0)
Fourth and above	114	16.2 (12.8, 20.3)	48	18.9 (14.1, 24.8)
	χ^2 = 19.99, p = 0.001		χ^2 = 27.42, p = 0.0002	
Small birth weight[d]				
No	74	6.6 (5.2, 8.4)	47	6.6 (4.8, 9.0)
Yes	32	18.3 (12.8, 25.3)	29	18.3 (11.8, 27.1)
	χ^2 = 48.54, p < 0.001		χ^2 = 29.06, p = 0.0003	
Recent morbidity status[e]				
No	11.2	11.2 (9.8, 12.7)	147	10.4 (8.4, 12.9)
Yes	297	11.8 (10.4, 13.5)	109	8.7 (6.7, 11.1)
	χ^2 = 0.53, p = 0.495		χ^2 = 2.32, p = 0.206	
Total	609	11.5 (10.4, 12.7)	256	9.6 (8.0, 11.5)

[a]defined as women's decision making power relative to their male partners

[b]exposure to either radio, television, newspapers, or magazines at least once a week

[c]integrating household asset ownership and access to drinking water and sanitation

[d]child's size and weight at birth based on a mother's perception

[e]child had at least one morbid condition out of diarrhea, fever and cough in the two weeks preceding the survey.

In urban areas, children of parents with no formal education (26%), children who lived in socio-economically poorest households (19%), children born with small birth weight (18%) and children of

underweight mothers (15%) reported a higher prevalence of severe under-5 malnutrition. In rural areas, children of parents with no formal education (22%), children born with small birth weight (18%), children of underweight mothers (17%) and children who lived in socio-economically poorest households (16%) reported a higher prevalence of severe under-5 malnutrition (Table 3).

Risk factors of severe under-5 malnutrition

The key risk factors for under-5 malnutrition in urban areas were: children born with small birth weight (OR: 5.03, 95% CI: 2.93, 8.63) vs normal/average weight; children of parents with no formal education (OR: 2.03, 95% CI: 1.16, 3.56) vs children of educated parents; children's birth order ≥ 4 (OR: 1.82, 95% CI: 1.19, 2.81) vs children's first birth order; and children of underweight mothers (OR: 1.72, 95% CI: 1.22, 2.43) vs normal mothers(Table 4).

Table 4
Risk factors of under-5 severe child undernutrition in urban context

Characteristics	Rural		Urban	
	Adjusted Odds Ratio (95% CI)	P values	Adjusted Odds Ratio (95% CI)	P values
Parents' education [a]				
Both parents with no formal education	1.51 (1.03, 2.22)	0.034	2.03 (1.16, 3.56)	0.014
Only father with no formal education	1.44 (1.14, 1.84)	0.003	1.16 (0.75, 1.81)	0.504
Only mother with no formal education	1.99 (1.32, 2.98)	0.001	1.06 (0.54, 2.07)	0.863
Both parents with no formal education (RC)	1.00		1.00	
Underweight mother (< 18.5 kg/m2) [a]				
No (RC)	1.00		1.00	
Yes	1.46 (1.18, 1.81)	< 0.001	1.72 (1.22, 2.43)	0.002
Mothers received antenatal care [b]				
No	1.06 (0.74, 1.51)	0.729	1.56 (0.84, 2.90)	0.156
Yes (RC)	1.00		1.00	
Mothers received postnatal care [b]				
No	0.83 (0.64, 1.08)	0.172	0.64 (0.43, 0.96)	0.033

RC, reference caregory

[a]model adjusted with all variables found significant in the bivariate analysis except mothers received antenatal care, mothers received postnatal care and small birth weight

[b]model adjusted with all variables found significant in the bivariate analysis including mothers received antenatal care, mothers received postnatal care and small birth weight

[c]exposure to either radio, television, newspapers, or magazines at least once a week

[d]integrating household asset ownership and access to drinking water and sanitation

[e]child's size and weight at birth based on a mother's perception

Characteristics	Rural		Urban	
	Adjusted Odds Ratio (95% CI)	P values	Adjusted Odds Ratio (95% CI)	P values
Yes (RC)	1.00		1.00	
Mothers experience IPV [a]				
No	1.00			
Yes	1.29 (1.05, 1.58)	0.014		
Solid waste use in cooking [a]				
No (RC)	1.00			
Yes	1.14 (0.87, 1.50)	0.335	1.05 (0.75, 1.48)	0.768
Type of toilet facility [a]				
Improved (RC)	1.00			
Unimproved	1.10 (0.90, 1.34)	0.365		
Mass media exposure [a,c]				
No	1.16 (0.96, 1.41)	0.134	1.08 (0.76, 1.53)	0.672
Yes (RC)	1.00		1.00	
Wealth index [a,d]				
Poorest	2.32 (1.43, 3.75)	0.001	1.61 (1.08, 2.39)	0.018
Poorer	2.14 (1.35, 3.41)	0.001	1.45 (0.98, 2.13)	0.061
Middle	1.65 (1.03, 2.65)	0.037	1.19 (0.85, 1.66)	0.318
Richer	1.74 (1.08, 2.81)	0.023	1.19 (0.92, 1.56)	0.187

RC, reference caregory

[a]model adjusted with all variables found significant in the bivariate analysis except mothers received antenatal care, mothers received postnatal care and small birth weight

[b]model adjusted with all variables found significant in the bivariate analysis including mothers received antenatal care, mothers received postnatal care and small birth weight

[c]exposure to either radio, television, newspapers, or magazines at least once a week

[d]integrating household asset ownership and access to drinking water and sanitation

[e]child's size and weight at birth based on a mother's perception

Characteristics	Rural		Urban	
	Adjusted Odds Ratio (95% CI)	P values	Adjusted Odds Ratio (95% CI)	P values
Richest (RC)	1.00		1.00	
Children age [a]				
0–11 months (RC)	1.00		1.00	
12–23 months	1.82 (1.38, 2.40)	< 0.001	1.15 (0.77, 1.73)	0.499
24–35 months	2.11 (1.60, 2.78)	< 0.001	1.40 (0.94, 2.09)	0.097
36–47 months	1.33 (0.99, 1.79)	0.061	0.91 (0.59, 1.41)	0.675
48–59 months	1.22 (0.91, 1.64)	0.192	0.84 (0.55, 1.29)	0.418
Birth order [a]				
First (RC)	1.00		1.00	
Second	1.04 (0.84, 1.30)	0.708	1.23 (0.89, 1.70)	0.214
Third	1.07 (0.83, 1.38)	0.619	1.23 (0.82, 1.85)	0.315
Fourth and above	1.23 (0.93, 1.61)	0.143	1.82 (1.19, 2.81)	0.006
Small birth weight [b,e]				
No (RC)	1.00		1.00	
Yes	2.35 (1.47, 3.76)	< 0.001	5.03 (2.93, 8.63)	< 0.001

RC, reference caregory

[a]model adjusted with all variables found significant in the bivariate analysis except mothers received antenatal care, mothers received postnatal care and small birth weight

[b]model adjusted with all variables found significant in the bivariate analysis including mothers received antenatal care, mothers received postnatal care and small birth weight

[c]exposure to either radio, television, newspapers, or magazines at least once a week

[d]integrating household asset ownership and access to drinking water and sanitation

[e]child's size and weight at birth based on a mother's perception

The key risk factors for under-5 malnutrition in rural areas were: children born with small birth weight (OR: 2.35, 95% CI: 1.47, 3.76) vs normal/average weight; children who lived in socio-economically poorest households (OR: 2.32, 95% CI: 1.43, 3.75) vs richest households; children aged less than 36 months ((for age group 24–35 months (OR: 2.11, 95% CI: 1.60, 2.78; for age group 12–23 months (OR: 1.82 95% CI: 1.38, 2.98) vs children of age group 0–11 months; children of mothers with no formal education (when fathers are educated) (OR: 1.99, 95% CI: 1.32, 2.98) vs children of educated parents (Table 4).

The risk difference of severe under-5 child malnutrition between children born with normal/average weight and low birth weight was 268% lower in rural areas than in urban areas. The risk difference between children of parents with formal education and no education was 52% lower in rural areas than in urban areas. On the other hand, the risk difference between children of wealthiest households and poorest households was 71% higher in rural areas than in urban areas (Table 5).

Table 5
Risk difference results from logistic regression analysis

Characteristics	RD_r with respect to RC (rural context)	RD_u with respect to RC (urban context)	Urban rural difference (RD_u - RD_r)
Parents' education			
Both parents with no formal education	0.51	1.03	0.52
Only father with no formal education	0.44	0.16	-0.28
Only mother with no formal education	0.99	0.06	-0.93
Both parents with no formal education (RC)	0.00	0.00	0.00
Underweight mother (< 18.5 kg/m2)			
No (RC)	0.00	0.00	0.00
Yes	0.46	0.72	0.26
Mothers received antenatal care			
No	0.06	0.56	0.50
Yes (RC)	0.00	0.00	0.00
Mothers received postnatal care			
No	-0.17	-0.36	-0.19
Yes (RC)	0.00	0.00	0.00
Mothers experience IPV			
No (RC)	0.00		
Yes	0.29		
Solid waste use in cooking			

RD_r, risk difference in rural context

RD_u, risk difference in urban context

RC, reference caregory

Characteristics	RD_r with respect to RC (rural context)	RD_u with respect to RC (urban context)	Urban rural difference (RD_u - RD_r)
No	0.00	0.00	0.00
Yes (RC)	0.14	0.05	-0.09
Type of toilet facility			
Improved (RC)	0.00		
Unimproved	0.10		
Mass media exposure			
No	0.16	0.08	-0.08
Yes (RC)	0.00	0.00	0.00
Wealth index			
Poorest	1.32	0.61	-0.71
Poorer	1.14	0.45	-0.69
Middle	0.65	0.19	-0.46
Richer	0.74	0.19	-0.55
Richest (RC)	0.00	0.00	0.00
Children age			
0–11 months (RC)	0.00	0.00	0.00
12–23 months	0.82	0.15	-0.67
24–35 months	1.11	0.40	-0.71
36–47 months	0.33	-0.09	-0.42
48–59 months	0.22	-0.16	-0.38
Birth order			
First (RC)	0.00	0.00	0.00
Second	0.04	0.23	0.19

RD_r, risk difference in rural context
RD_u, risk difference in urban context
RC, reference caregory

Characteristics	RD_r with respect to RC (rural context)	RD_u with respect to RC (urban context)	Urban rural difference (RD_u - RD_r)
Third	0.07	0.23	0.16
Fourth and above	0.23	0.82	0.59
Small birth weight			
No (RC)	0.00	0.00	0.00
Yes	1.35	4.03	2.68
RD_r, risk difference in rural context			
$RD_{u,}$ risk difference in urban context			
RC, reference caregory			

Discussion

The overall burden of severe under-5 child malnutrition using the aggregated CISAF values was 11% (12% in rural areas and 10% in urban areas). In contrast, in the same population, the prevalence of severe stunting among children under-5 was 9%. One may speculate that overlap of conventional indicators (i.e. severe stunting, severe wasting and severe underweight) can partly explain this finding. Conventional indicators, therefore, may not provide a comprehensive estimate of the proportion of malnourished children in the population. In contrast, CISAF uses conventional nutritional indicators' aggregate values to estimate the overall burden of severe malnutrition, thus provide a more convincing estimation of the proportion of malnourished children in the population [10]. Our finding of a higher prevalence of severe under-5 malnutrition in rural areas concurs with previous research [20,21,22,23]. Several studies have also reported a higher prevalence of severe under-5 malnutrition in urban areas in Bangladesh with limited geographical coverage [24,25,26]. It should be noted that the rural population is overrepresented in our data, with two out of three (66%) children included in our study lived in rural areas. Approximately 63% of the Bangladeshi population residing in rural areas [27], thus our findings provide an accurate picture of the severe under-5 malnutrition in the country.

The prevalence of severe under-5 child malnutrition was high for children of parents with no formal education. One in four children of parents with no formal education experienced severe malnutrition regardless of being born in rural or urban areas. Further, low birth weight children had a greater odd of being severely malnourish regardless of the rural or urban context. For example, children with low birth weight experienced severe malnutrition 5.03 times more if they lived in urban areas and 2.35 times more if they lived in rural areas. Also, one in five under-5 children born in rural and urban areas with a small birth weight experienced severe malnutrition. Previous studies in Pakistan, Nepal, Malawi, Mexico and Iran also reported children born with small birth weight were more likely to explore malnutrition

[13,28,29,3031]. Children born with a low birth weight generally increase their height and weight by small increments [32]. Thus, they may remain shorter and lighter and might be severely malnourished without adequate nutrition support. Children with small birth weights are often born to households with low socio-economic status and poor maternal health conditions [33]. Inadequate feeding practice can contribute to developing under-5 malnutrition due to the irregular distribution of food for children in socio-economically poor households and the knowledge gap of parents/caregivers for appropriate feeding practice. Maternal/parental illiteracy is often associated with low birth weight of child and other determinants including poor maternal healthcare access and caregiving to children, contributing to adverse nutritional outcomes of mothers and children [34, 35]. In our study, 7% of parents were illiterate and 7% of child born with small birth weight that justified the interlink of malnutrition, parental literacy and small birth weight.

Poor socio-economic status is an established risk factor for severe stunting among under-5 children [3,18,36,37]. One in five children who lived in socio-economically poorest households experienced severe under-5 malnutrition. The odds of severe under-5 malnutrition were 2.32 times higher for children lived in rural areas and 1.61 folds higher for those who lived in urban areas if their household was socio-economically poorest. Parents of socio-economically poorest households often can not afford a minimum diet for their children [38].

Parental illiteracy affects children's adverse nutritional outcomes in urban areas, with odds of severe under-5 malnutrition were 2.03 folds higher. In contrast, being born to mothers with no formal education was identified as the most influential risk factor of malnutrition urban areas of Bangladesh [20]. In rural Ethiopia, maternal illiteracy affected children's nutritional status but not a significant risk factor in Pakistan [39,40]. Parental education is a risk factor not been previously reported in Bangladesh and a novel finding of our study. The cost of living is high in urban areas. Educated parents are presented with better job opportunities and higher income, thus can adequately support their children.

Children's birth order ≥ 4 were 1.82 times more likely to experience severely malnourish if they live in urban areas. In a study in Bangladesh by Akram et al. (2018) found children in higher birth order were more likely of being severely malnourished in urban areas, on the other hand, children in higher birth order had more chance of being severely malnourished in rural areas in India [20,41]. Previous studies from Bangladesh, Congo and Ethiopia also reported children with higher birth order were more likely to explore malnutrition regardless of urban-rural context [42,43,44]. Food competition among household's members and the preference of elderly children might cause malnutrition in younger children [2]. The risk of severe malnutrition is usually high in older children (i.e. age 4 to 5 years) in Bangladesh, Nepal, Pakistan, Ethiopia and Congo [45,46,47,48,49]. In comparison, severe malnutrition is high in younger (age 1 to 2 years) children in India [50], indicating this problem's complex nature. We found that toddlers (age 2 to 3 years) living in rural areas had higher odds of severe under-5 malnutrition but not toddlers living in urban areas. Similar level of provision of health and nutritional care available urban children might be the reason of insignificant association between children age and severe malnutrition. Inappropriate feeding behaviours at 6–36 months, and other factors (e.g. infection and food shortage), may be responsible for one-third of malnutrition cases, depending on population, place, time, and season [51]. In addition, lack of

attention in rural areas (urban-rural disparities) in case of receiving complementary feeding, access to health services, preventive and curative interventions influence nutrition outcomes [52].

Theoretical insights based on the CISAF aggregated analysis indicates that context-specific individual, community, public policy and environment level of risk factors need to be addressed. The risk difference of severe under-5 child malnutrition between parents with formal education and no formal education was lower in rural areas than in urban areas. Similarly, the risk differences of severe under-5 child malnutrition between children of healthy weight mothers and underweight mothers was lower in rural than that of urban areas. It is possible that in a rural setting, educational attainment and access to health and nutritional care, may not be enough to reduce the burden of severe under-5 child malnutrition owing to the complex interplay between risk factors. Svere malnutrition is a multifaceted, complex phenomenon, involving many immediate causes (such as, insufficient diet habit, child diarrhoea, and ages of breastfeeding children) and underlying causes (such as, income inequality, food insecurity, household dietary diversity, age of introduction of complementary food, access to safe water and environmental hygiene) [53,54]. The risk difference between most affluent and poorest was higher among children in rural areas than urban areas, indicating greater rich-poor gap in rural areas. Socio-economic inequality can be reduced by increasing income-generating activities driven by public and private entities. Such endeavours need to be aimed at deprived and vulnerable individuals and ensure their participation with a standard wage structure under the national nutritional security system. Economic development is associated with improved nutritional status via reducing malnutrition [55]. Improved per capita household income increases available funds for food expenditure and basic health care needs, improving children's nutritional status. Empirical education and standard health care should be made available and accessible to all women in urban and rural areas. Improving access to community-based/empirical education and standard health care to mother will confer many benefits from improved caregiver practices, enhance health and environmental knowledge; increase educated and skilled workforce; live in better neighborhoods, reduce gender-based violence; reduces child marriage and early childbearing; reduces maternal death rates in terms of improved nutritional status and child development [56].

Limitations

The BDHSs data used for this study was the largest nationally representative sample in Bangladesh and the stability of the data set allows changes over time to be monitored with some confidence. However, the cross-sectional data was insufficient to establish a causal relationship, consequently limiting the findings' applicability. Further, data on potential confounders like diet, food insecurity and parents smoking behaviour were unavailable. The BDHS data were collected retrospectively and self-reported, thus subject to underreporting, information bias and recall bias. However, data were collected using validated tools and standard procedures. Using seven nutritional status measurements, CISAF provided a credible estimate of the overall proportion of severe under-5 child malnutrition and the complex interplay between individual, community, public policy and environment level risk factors.

Conclusion

The overall prevalence of severe under-5 child malnutrition was greater than conventional indicators. One in ten children living in both rural and urban areas experience severe malnutrition. Children of parents with no formal education, children of underweight mothers, those living in socio-economically poorest households and children of small birth weight experienced severe malnutrition regardless of setting. Rural areas were identified as greater rich-poor gap. Educational attainments and access to health and nutritional care may not be enough to reduce the burden of severe under-5 child malnutrition in rural settings due to the complex interplay between risk factors. Context-specific interventions addressing individual, community, public policy and environment level of risk factors need to reduce structural and intermediary determinants of under-5 severe malnutrition.

Declarations

Ethics approval and consent to participate:

No ethical approval was needed for this study since it was based on secondary analysis of the data obtained from Bangladesh Demographic and Health Survey (BDHSs) during 2017-18. The BDHSs was reviewed and approved by the ICF Macro Institutional Review Board (USA), which complies with all of the requirements of 45 CFR 46 "Protection of Human Subjects". The Bangladesh DHS was also reviewed and approved by the National Research Ethics Committee of the Bangladesh Medical Research Council (Dhaka, Bangladesh). The survey ensured international ethical standards of confidentiality, anonymity, and informed consent. However, request to access datasets from measure DHS website is made and the websites has allowed the same before analyses is made.

Consent for publication:

Not applicable.

Availability of data and materials:

The data underlying the results presented in the study are publicly accessible and available from DHS website (https://dhsprogram.com/data/available-datasets.cfm). Name of the dataset is Bangladesh Demographic and Health Survey (BDHS).

Competing interests:

The authors declare that they have no competing interests.

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Authors’ contributions:

MRKC conceptualized the basic idea for the study, performed the statistical analysis together with AIA. MRKC and AIA prepared data for analysis. MRKC, AIA, MK prepared the first draft of the manuscript. HTAK, MNIM and NKPP critically revised the manuscript for intellectual content. All authors have reviewed and approved the final manuscript.

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Figures

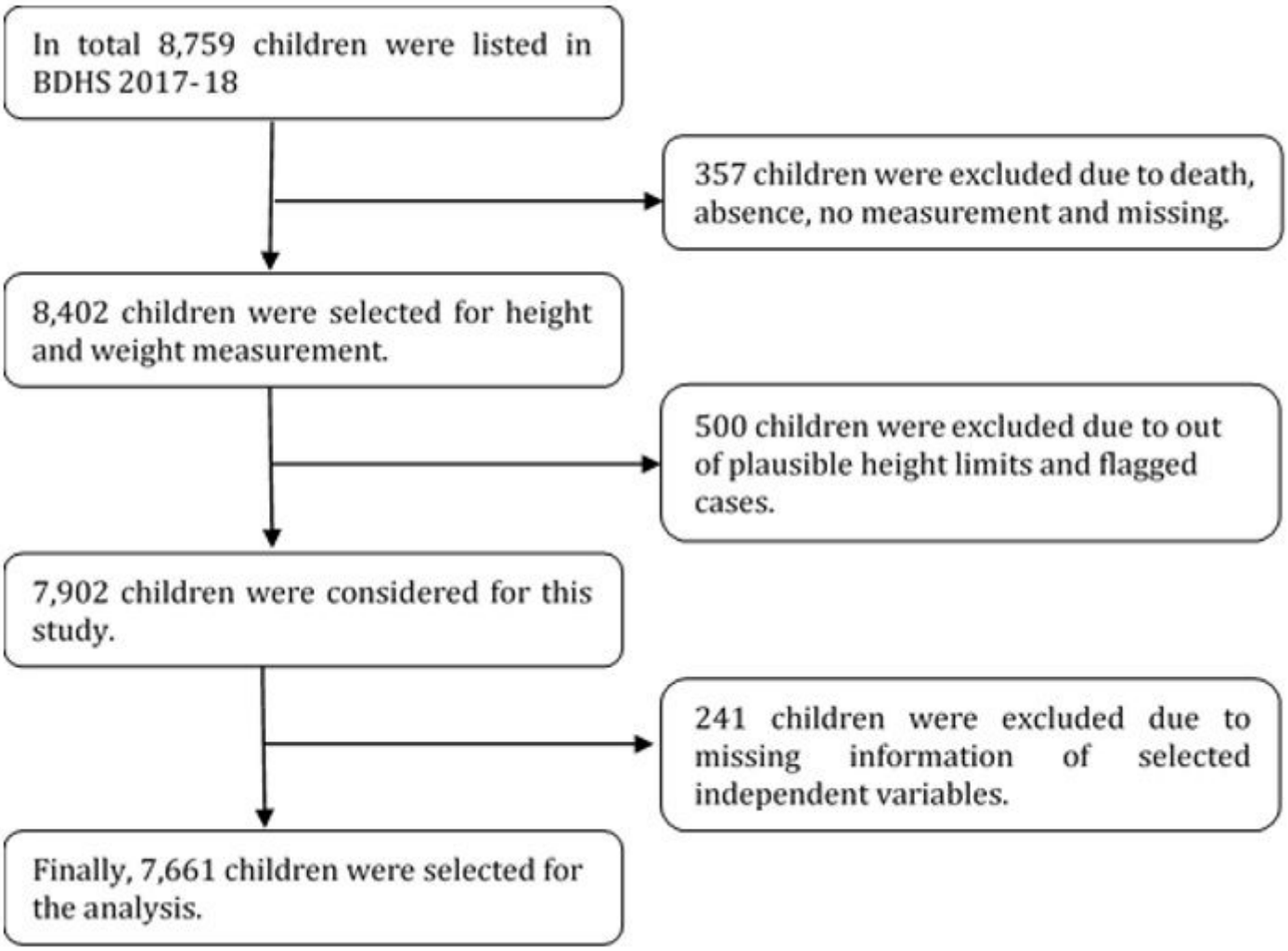

Figure 1

sample size selection

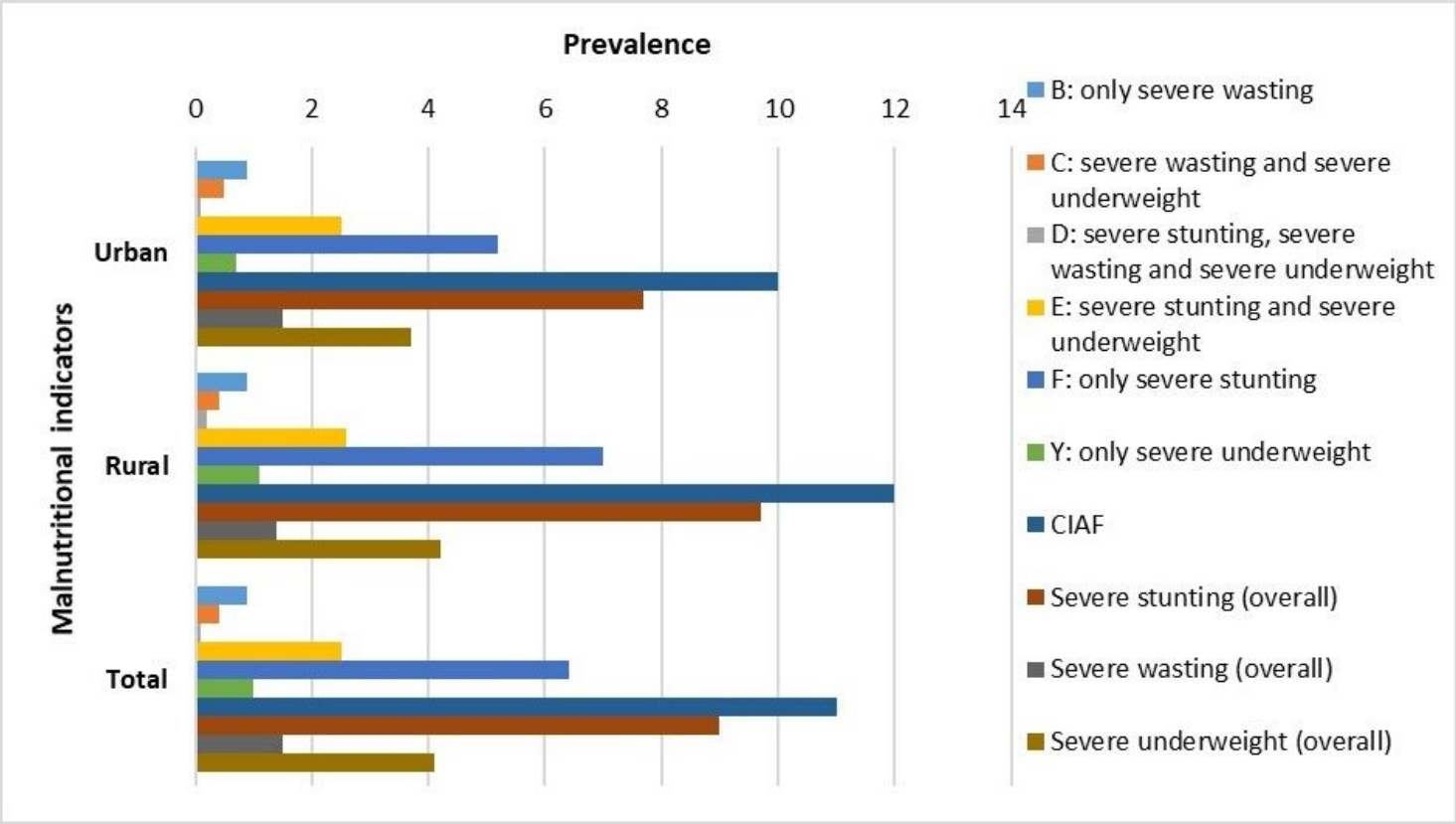

Figure 2

Prevalence of malnutritional indicators

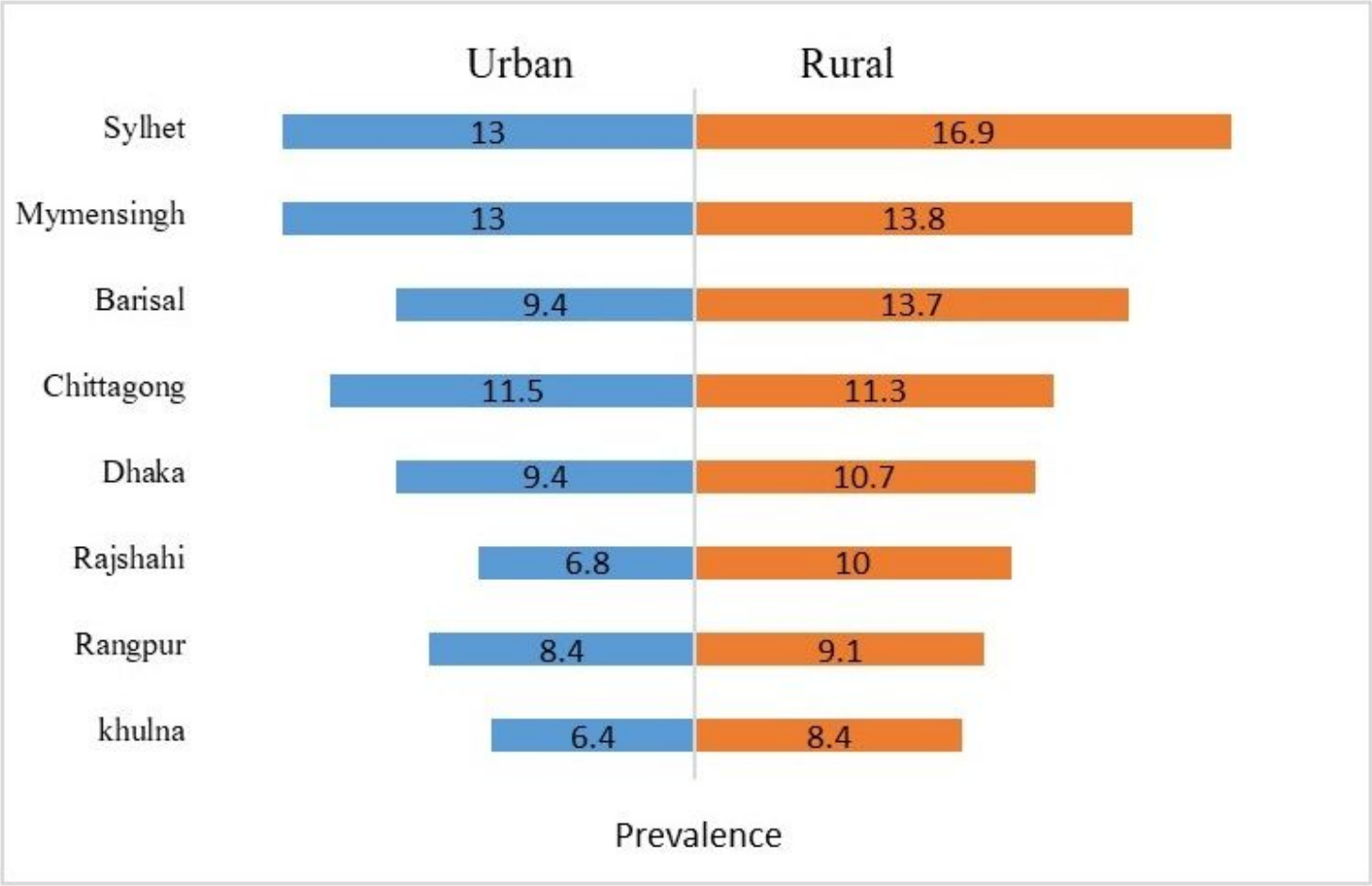

Figure 3

Regional prevalence in urban-rural context