Clinical Epidemiology and Global Health 20 (2023) 101256

Contents lists available at ScienceDirect

Clinical Epidemiology and Global Health

journal homepage: www.elsevier.com/locate/cegh

Exploring the association between child nutritional disorders and short birth interval: Evidence from 2017/18 Bangladesh Demographic and Health Survey data

Mohammad Zahidul Islam [a,b], Mostafizur Rahman [b], Nuruzzaman Khan [a,*]

[a] Department of Population Science, Jatiya Kabi Kazi Nazrul Islam University, Trishal, Mymensingh, Bangladesh
[b] Department of Population Science and Human Resource Development, Rajshahi University, Bangladesh

ARTICLE INFO

Keywords:
Child nutritional disorder
Short birth interval
Low and middle-income countries
Bangladesh

ABSTRACT

Background: Nutritional disorder is an ongoing public health threat in Low- and Middle-Income Countries (LMICs) which is assumed to be higher among children born in shorter intervals (Short Birth Interval, SBI). However, high-quality research addressing this is lacking. We explored the association of nutritional disorder with SBI adjusting for possible confounders.

Methods: We linked 5941 mother-child dyads included in 2017/18 Bangladesh Demographic and Health Survey with 1524 healthcare facilities included in the 2017 Bangladesh Health Facility Survey and analysed. Three forms of nutritional disorders were considered as outcome variables: stunting, wasting, and underweight. The major exposure variable was SBI. The multilevel Poisson regression model was used separately for each outcome to explore the association between exposure and outcome variables, adjusting for possible confounders at the individual-, household-, community- and health facility levels.

Results: Almost 26% of the total children analysed were born in SBI among which the reported prevalence of stunting, wasting, and underweight was almost 30%, 22% and 29%, respectively. Children born in the SBI had a 1.20 times (aOR, 1.20, 95% CI, 1.08–1.33) higher likelihood of being stunted and a 1.14 times (aOR, 1.14, 95% CI, 1.00–1.30%) higher likelihood of being underweighted than their counterparts born in the normal interval. The association between wasting and SBI was not found statistically significant.

Conclusion: This study confirms that SBI increases the occurrence of child nutritional disorders. Programs to aware mothers about the risk of close intervals children on becoming undernourished should be considered in national level policies and programs.

1. Background

Nutritional disorders among under-five children, including stunting (low height for age), wasting (low weight for height), and underweight (low weight for age), are an ongoing public health threat with a net number of 149 million, 45 million, and 462 million in 2020, respectively.[1] A majority of them occur in low- and middle-income countries (LMICs), particularly in the Asian countries where the prevalence of stunting, wasting, and underweight are 21.8%, 6.7% and 20%, respectively.[2] Bangladesh, a South Asian country with approximately 4 million children born each year, contributes significantly to the total number of nutritionally disordered children in South Asia.[3] The prevalence of stunting, wasting, and underweight in Bangladesh are 22%, 6.6%, and 21.9%, respectively – a figure which is higher than the average of other Asian countries and the global average (stunting, 22%, wasting 6.6%).[2,3] The major reasons for such higher prevalence of nutritional disorders in LMICs, including in Asian countries and Bangladesh, are poor quality diets, poor sanitation, higher prevalence of communicable diseases, including diarrhea, and inadequate child healthcare services.[1,2,4]

Nutritional disorder poses several burdens to a country, including an increasing rate of child morbidity (e.g., diarrhea and pneumonia) and related hospitalization rate which further increase the county's health expenditure and create additional pressure to the existing healthcare facility.[5,6] It also affects the long-term development of children,

Abbreviations: LMICs, Low- and Middle Income Countries; SDGs, Sustainable Development Goals; WHO, World Health Organization; BDHS, Bangladesh Demographic and Health Survey; NIPROT, National Institute of Population Research and Training; aPR, Adjusted Prevalence Ratio; 95% CI, 95% Confidence Interval.

* Corresponding author. Department of Population Science, Jatiya Kabi Kazi Nazrul Islam University, Mymensingh, Bangladesh.
E-mail address: sumonrupop@gmail.com (N. Khan).

https://doi.org/10.1016/j.cegh.2023.101256
Received 26 July 2022; Received in revised form 13 December 2022; Accepted 14 February 2023
Available online 16 February 2023

including physical development and educational performance.[7] Moreover, around 45% of the global occurrence of under-five deaths are found to be linked with child nutritional disorders,[1] a rate which is 14 times higher in LMICs than in developed countries.[8] Together these indicate challenges for LMICs, particularly to achieve the relevant targets set in the Sustainable Development Goals (SDGs) to be achieved by 2030, including targets to reduce neonatal mortality (12 per 1000 live birth), under-five mortality (25 per 1000 live birth) as well as ensuring health and wellbeing for all.[9]

As per the recommendation of the World Health Organization (WHO), a birth is considered as short interval birth (SBI) if it is occurred within 33 months of the immediately preceding birth.[10] The global prevalence of SBI is nearly 25% which is further higher in sub-Saharan African region (57%) followed by Central Asian region (33%).[1,10] The prevalence of SBI in Bangladesh is 26%- a rate which is comparable to the global prevalence, however, the actual number is very high with around 1 million live births yearly.[10]

SBI is found to be linked with nutritional disorders in several LMICs.[11–15] However, research addressing this issue is scarce in Asian countries[16–18] and Bangladesh.[3,19–21] Available research are limited to the analysis of a small sample, an inadequate list of confounding factors, and the use of imprecise analysis techniques. They mainly considered mothers' socio-demographic characteristics, rather than focusing on pregnancy-related characteristics, as a potential determinant of child nutritional disorder.[3,16–21] Moreover, healthcare facility plays an important role in treating the nutritional disorder and providing related counselling in LMICs, including Bangladesh.[22] Therefore, healthcare facility level factors might have a direct relationship with child nutritional disorder and indirectly mediate the socio-demographic factors' contribution to child nutritional disorder.[10]- However, none of the available studies in LMICs considered healthcare facility level factors as a potential determinant of child nutritional disorder and/or adjust their influence in determining the predictors of child nutritional disorder. To address these limitations, we conducted this study to explore the associations of SBI with stunting, wasting and underweight adjusted for individual-, household-, community-, and health facility-level factors.

2. Methods

The most recent 2017/18 Bangladesh Demographic and Health Survey (BDHS) data and 2017 Bangladesh Health Facility Survey (BHFS) data were linked and analysed. The sampling procedure of both surveys can be found in the respective survey reports.[22,23]

The National Institute of Population Research and Training, a government organization that works under the Ministry of Health and Family Welfare, conducts the BDHS every three years as part of the Demographic and Health Survey Program of the USA. Financial and technical support to conduct this survey was provided by several development partners of Bangladesh, including the United Nations Population Fund (UNFPA) and the United Nations Development Programme (UNDP).

The survey collected data from nationally representative households selected by using a two-stage stratified random sampling method. At the first stage, 675 clusters were selected randomly from the list of 293,579 clusters generated by the Bangladesh Bureau of Statistics to conduct the Bangladesh National Population Census 2011. Three of them were excluded due to flood and the remaining 672 clusters were finally chosen for data collection. A fixed number of 30 households were then selected from each cluster by systematic random sampling method at the second stage of sampling. This produced a list of 20,160 households among which data collection was undertaken in 19,457 households with a response rate of 96.5%. There were 20, 378 eligible women (ever married reproductive aged (15–45 years) women who are usual residents of the selected households or passed the most recent night before the date of the survey) in these selected households, of them data were collected from 20,127 women with a response rate of 98.8%.

The 2017 BHFS is the source of healthcare facility data. The survey collected data from 1524 healthcare facilities selected proportionately from the public, private and non-government sectors. Both census and stratified random sampling methods were used to select these facilities from the 19,811 registered healthcare facilities in Bangladesh.

The GPS point locations are available for each of the 672 clusters included in the 2017 BDHS and 1524 healthcare facilities included in the 2017 BHFS. We linked the clusters with the nearest healthcare facilities using the administrative boundary linkage method. The details of this method have been published elsewhere.[10,24] The geographical linkage between the BDHS and BHFS data was performed using the Statistical Package R (version 4.2.0). All other statistical analyses were conducted using Stata version 15.1 (Stata Corp, College Station, Texas, USA).

3. Sample

Of the collected data, 5941 mother-child dyads meet the inclusion criteria, as such, they were analysed in this study. The inclusion criteria were, i) women had at least two pregnancies, of which the most recent one ended with a live birth within previous five years of the survey date, (ii) the second most recent pregnancy occurred either with live birth or termination, (iii) preceding birth intervals (interval between the two most recent sub-sequent pregnancies) were recorded and iv) anthropometric information (height, weight) were recorded. It is important to note that the first three criteria were imposed by the survey to record the birth intervals data.

4. Outcome variable

Stunting (low height for age; no *vs* yes), wasting (low weight for height; no *vs* yes), and underweight (low weight for age; no *vs* yes) were our outcomes of interest. The survey recorded the height and weight of the under-five aged children of the interviewed mothers. We reclassified this information to generate the outcome variables, by following the WHO child growth standards.[25] A child is classified as stunted if the height-for-age Z-score is below minus two standard deviations (−2 SD) from the median of the reference population. Similarly, a child was classified as wasted if the weight-for-height Z-score is below minus two standard deviations (−2 SD) from the median of the reference population and a child is considered as underweighted if the weight-for-age Z-score is below minus two standard deviations (−2SD) from the median of the reference population.[25]

5. Exposure variables

Birth interval was our primary exposure of interest classified as the short birth interval (<33 months interval between the two most recent births) and normal birth interval (≥33 months interval between the two most recent births). The classification was done by following the relevant WHO recommendation.[26]

A comprehensive literature search was conducted in five databases (Medline, Embase, Web of Science, CINHAL, and Google Scholar) to identify the potential covariates of the association between SBI and nutritional disorders.[3,11–21] For this, priority was given to the study conducted in Asian countries, particularly in Bangladesh.[3,19–21] The factors identified and later available in the dataset were first considered. The associations of the considered variables with the SBI were then explored using the forward regression approach. The factors that were found to be significant at the $p < 0.20$ were retrained in the analysis. Finally, these factors, we summarized these factors as individual-, household-, community-, and health-facility level factors. The individual-level factors were maternal age at birth (≤19, 20–34, ≥35 years), maternal age at first birth (used as a continuous variable), mother's educational status (no education, primary, secondary, higher), and mothers' formal employment status at the time of the survey (employed, unemployed). Mothers' partners educational status (no education, primary, secondary, higher), sex of the household's head (male, female), total number of children ever given birth (≤2, >2), exposure to mass media (little exposed, moderately exposed, highly exposed), survival status of the child born from the second most recent pregnancy (yes, no), and wealth quintile (poorest, poorer, middle, richer, richest) were considered as household level factors. The community level factors included were the place of residence (urban, rural) and division (Barishal, Chattogram, Dhaka, Khulna, Mymensingh, Rajshahi, Rangpur, Sylhet). Other community level factors included were community level literacy (low [<21.0], moderate [21.0–50.0], high [>50.0]), community level poverty (high [>41.0], moderate [16.0–41.0], low [≤15.0], and middle and richest community), and community level fertility (low (≤2.10), high (>2.10)). Details of these community-level variables making procedures have been published elsewhere.[27] The average distance between under-five-aged children's mothers home and the nearest healthcare facility, where child healthcare services are available, was included as the health facility-level factor.

6. Statistical analysis

Descriptive statistics, with frequency and percentage distribution, were used to describe the characteristics of the respondents. The distribution of stunting, wasting, and underweight across exposure variables considered were also presented. Statistical significance of the differences in stunting, wasting, and underweight across explanatory variables were explored by using the chi-square test. In the BDHS, individuals were nested within a household, and households were nested within a PSU. Therefore, responses from the same household and cluster would behave more similarly than those from different households and clusters.[10,27] Moreover, the prevalence of the outcome variable was comparatively higher with more than 10% prevalence. Previous research has found that simple logistic regression models often overestimate the odds for hierarchical data and outcomes with comparatively higher prevalence.[28] Therefore, we used a multilevel Poisson regression model that accounts for these multiple hierarchies and dependency as well as the problem of overestimation.[10] Four models were run separately. Model 1 included all individual- and household-level factors. Model 2 included community-level factors. In model 3, the health facility-level variable was included. Model 4 was the final model that included all individual-, household-, community-, and health-facility level factors. Multicollinearity was also checked. If evidence of multicollinearity was found (VIF>10), the relevant variable was deleted, and the model was run again. Results were reported as Prevalence Ratios (PR) with 95% Confidence Intervals (95% CI). The Intra-class correlation coefficient was also recorded. The ICC values were calculated by dividing the between-clusters-variances of stunting, wasting, and underweight (random intercept variances) by their respective total variance (sum of between-clusters-variance and within-cluster (residual) variance of stunting, wasting, and underweight).

7. Result

7.1. Socio-demographic characteristics of the respondents and prevalence of SBI

The background characteristics of the respondents are presented in Table 1. Of the women analysed, a majority were given their last birth between their aged 20–34 years (86.24%) followed by 7.80% in women aged ≤19 years and 5.96% in women aged ≥35 years. Almost, half of the respondents analysed had secondary level education and only 13.91% of the total respondents reported themselves as the head of their household. Birth in the short interval was reported by around 26% of the total respondents.

Table 1
Background characteristics of the respondents.

Characteristics	Frequency	Prevalence (95% CI)
Birth interval		
Not in short birth interval	4375	73.64 (72.06–75.16)
Short birth interval	1566	26.36 (24.84–27.94)
Maternal age at birth		
≤19	464	7.80 (6.89–8.82)
20-34	5123	86.24 (85.06–87.34)
≥35	354	5.96 (5.35–6.64)
Maternal age at first birth		
≤19	4467	75.19 (73.52–76.80)
20-34	1468	24.71 (23.10–26.39)
≥35	6	0.10 (.036–0.28)
Mother's educational status		
No education	568	9.55 (8.44–10/79)
Primary	1961	33.01 (31.14–34.93)
Secondary	2794	47.03 (45.06–49.01)
Higher	618	10.41 (9.22–11.73)
Mothers' formal employment		
Yes	2781	46.81 (44.39–49.24)
No	3160	53.19 (50.76–55.61)
Mothers' partners educational status		
No education	1079	18.43 (16.78–20.20)
Primary	2179	37.22 (35.49–38.98)
Secondary	1751	29.91 (28.30–31.57)
Higher	846	14.44 (13.13–15.86)
Sex of the household's head		
Male	5114	86.09 (84.61–87.45)
Female	827	13.91 (12.55–15.39)
Total children ever born		
≤2	3075	51.75 (49.86–53.64)
>2	2866	48.25 (46.36–50.14)
Exposure to mass media		
Little exposed	2289	38.52 (35.83–41.29)
Moderately exposed	2864	13.26 (12.12–14.50)
Highly exposed	788	48.21 (45.57–50.86)
Child born from the second most pregnancy was alive		
Yes	5459	91.88 (90.85–92.80)
No	482	8.12 (7.20–9.15)
Wealth quintile		
Poorest	1439	24.22 (21.85–26.76)
Poorer	1286	21.65 (19.92–23.48)
Middle	1067	17.95 (16.50–19.51)
Richer	1097	18.47 (16.76–20.31)
Richest	1052	17.71 (16.01–19.55)
Type of residential place		
Urban	1543	25.97 (24.31–27.71)
Rural	4398	74.03 (72.29–75.69)
Administrative division		
Barishal	334	5.61 (4.98–6.32)
Chattogram	1312	22.08 (20.32–23.94)
Dhaka	1466	24.67 (22.77–26.67)
Khulna	502	8.45 (7.62–9.36)
Mymensingh	507	8.54 (7.69–9.48)
Rajshahi	643	10.82 (9.63–12.14)
Rangpur	625	10.53 (9.51–11.64)
Sylhet	552	9.30 (8.22–10.5)

7.2. Distribution of stunting, wasting, and underweight across socio-demographic characteristics

The estimated prevalence of stunting, wasting, and underweight across socio-demographic characteristics of the respondents are presented in Table 2. As compared to the children born in normal intervals, the prevalence of stunting (30%), wasting (22%) and underweight (29%) were found higher among the children born in shorter intervals. A higher prevalence of stunting, wasting, and underweight was also found among children of the poorest households, rural children, and children in the Chattogram and Dhaka divisions. A higher rate of stunting (51%), wasting (46%), and underweight (51%) was found among children of working mothers as compared to the children of unemployed mothers. The prevalence of stunting, wasting, and underweight was found to be low (8%) among mothers whose partners were highly educated as

Table 2
Distribution of stunting, wasting and underweight across socio-demographic characteristics.

Characteristics	Stunting	P-value	Wasting	p-value	Underweight	P-value
Birth interval						
Not in short birth interval	70.09 (67.42–72.62)	0.000	78.03 (73.37–82.07)_	0.1531	71.04 (67.82–74.07)	0.0009
Short birth interval	29.91 (27.38–32.58)		21.97 (17.93–26.63)		28.96 (25.93–32.18)	
Maternal age at birth						
≤19	8.00 (6.60–9.67)	0.127	6.89 (4.73–9.95)		7.82 (6.15–9.91)	0.079
20-34	85.70 (83.60–87.58)		87.13 (83.24–90.22)		84.98 (82.51–87.15)	
≥35	6.29 (5.13–7.71)		5.98 (3.98–8.88)	0.9965	7.20 (5.82–8.86)	
Maternal age at first birth						
≤19	79.00 (76.59–81.22)	0.001	79.81 (75.13–83.79)		78.48 (75.68–81.03)	0.029
20-34	21.00 (18.78–23.41)		20.19 (16.21–24.87)		21.52 (18.97–24.32)	
≥35	0		0		0	
Mother's educational status						
No education	12.32 (10.43–14.51)	0.000	14.02 (10.88–17.90)	0.0050	14.79 (12.38–17.58)	0.000
Primary	39.18 (36.18–42.25)		32.14 (27.22–37.48)		37.76 (34.25–41.41)	
Secondary	43.94 (40.81–47.11)		46.91 (41.45–52.45)		42.44 (38.74–46.23)	
Higher	4.56 (3.53–5.88)		6.92 (4.71–10.06)		5.00 (3.73–6.68)	
Mothers' formal employment						
Yes	51.15 (47.75–54.53)	0.000	45.58 (39.95–51.32)	0.6206	50.83 (47.12–54.53)	0.005
No	48.85 (45.47–52.25)		54.42 (48.68–60.05)		49.17 (45.47–52.88)	
Mothers' partners educational status						
No education	23.95 (21.37–26.73)	0.000	20.18 (16.47–24.49)	0.0813	24.57 (21.72–27.67)	0.000
Primary	42.75 (39.97–45.58)		36.84 (32.12–41.83)		40.59 (37.60–43.65)	
Secondary	25.36 (22.99–27.88)		32.99 (24.85–37.87)		26.46 (23.76–29.35)	
Higher	7.94 (6.52–9.65)		9.99 (7.22–13.65)		8.38 (6.72–10.40)	
Sex of the household's head						
Male	86.76 (84.46–88.77)	0.295	86.72 (82.69–89.93)	0.6421	88.82 (86.26–90.95)	0.008
Female	13.24 (11.23–15.54)		13.28 (10.07–17.31)		11.18 (9.05–13.74)	
Total children ever born						
≤2	46.18 (43.04–49.35)	0.000	51.29 (46.02–56.53)	0.7825	45.68 (42.02–49.38)	0.000
>2	53.82 (50.65–56.96)		48.71 (43.47–53.98)		54.32 (50.62–57.98)	
Exposure to mass media						
Little exposed	47.63 (43.88–51.42)	0.000	40.26 (34.68–46.12)	0..3744	47.24 (43.17–51.35)	0.000
Moderately exposed	12.01 (10.24–14.03)		44.78 (39.13–50.56)		12.39 (10.28–14.84)	
Highly exposed	40.36 (36.95–43.86)		14.96 (11.55–19.16)		40.38 (36.42–44.46)	
Child born from the second most pregnancy was alive						
Yes	92.08 (90.53–93.40)	0.003	93.77 (90.85–95.80)	0.9587	93.18 (91.54–94.51)	0.390
No	7.92 (6.60–9.47)		6.23 (4.20–9.15)		6.82 (5.49–8.46)	
Wealth quintile						
Poorest	30.95 (27.40–34.74)	0.000	28.21 (23.28–33.74)	0.2603	31.09 (27.02–35.49)	0.000
Poorer	25.52 (22.80–28.44)		19.92 (15.91–24.64)		24.83 (21.79–28.13)	
Middle	17.73 (15.50–20.21)		16.65 (13.03–21.02)		16.66 (14.03–19.67)	
Richer	15.77 (13.41–18.46)		20.56 (16.33–25.55)		17.39 (14.61–20.57)	
Richest	10.03 (8.35–12.00)		14.66 (11.10–19.12)		10.03 (8.13–12.32)	
Type of residential place						
Urban	20.55 (18.06–23.30)	0.000	28.18 (23.62–33.23)	0.1451	22.48 (19.29–26.03)	0.074
Rural	79.45 (76.70–81.94)		71.82 (66.77–76.38)		77.52 (73.97–80.71)	
Administrative division						
Barishal	6.19 (5.22–7.32)	0.000	6.23 (4.65–8.29)	0.4805	6.26 (5.16–7.58)	0.000
Chattogram	23.68 (20.65–26.99)		21.15 (16.87–26.17)		21.82 (18.55–25.49)	
Dhaka	19.15 (16.46–22.17)		26.21 (21.33–31.74)		20.32 (16.84–24.30)	
Khulna	7.46 (6.18–8.97)		8.05 (5.70–11.25)		7.12 (5.67–8.91)	
Mymensingh	9.93 (8.51–11.57)		9.38 (7.20–12.13)		9.81 (8.26–11.61)	
Rajshahi	10.03 (8.29–12.08)		9.51 (6.74–13.25)		11.16 (9.03–13.71)	
Rangpur	10.26 (8.70–12.07)		8.45 (5.95–11.86)		9.37 (7.61–11.49)	
Sylhet	13.30 (11.35–15.53)		11.04 (8.56–14.12)		14.14 (11.57–17.17)	

compared to the mothers whose partners were illiterate.

7.3. Model selection

Of the four different models run separately for each of the outcome variables, the AIC, BIC and ICC values were compared to select the best model. The preferred model was the one that had the smallest AIC, BIC and ICC (Table 3). According to these markers, Model 4 (including individual-, household-, community-level, and health facility level factors) fitted the data better for each of the outcome variables. The ICC values for the null models (Model 1) suggested around 26%, 24% and 28% of the differences in the occurrence of stunting, wasting, and underweight, respectively, across clusters included in the survey. However, these values were reduced to 6%, 3%, and 8%, respectively for stunting, wasting, and underweight once individual-, household- and community, and health-facility level factors were adjusted in the final model (Model 4).

7.4. Association of SBI with stunting, wasting and underweight

The prevalence ratio of stunting, wasting, and underweight obtained from the final model (model 4) are presented in Table 4. Supplementary Tables 1–3 show the results of full models. We found the likelihood of stunting was 1.20 times (aPR, 1.20, 95% CI, 1.08–1.33) higher among children born in shorter intervals as compared to the children born in normal intervals. In addition, children born in short intervals had a 14% higher likelihood of being underweight (aPR, 1.14, 95% CI, 1.01–1.30) than children born in normal intervals. However, the association between SBI and wasting was not found statistically significant.

The aPRs of stunting, wasting, and underweight decreased with

Table 3
Intra-class correlation and variances for random intercepts for stunting and underweight, 2017/18 BDHS.

	Stunting (ref: non-stunting)	Wasting (ref: non-wasting)	Underweight (ref: non-underweight)
Intra-Class Correlation (ICC)[a]			
Null model	0.26***	0.24***	0.28***
Individual- and household-level model	0.09***	0.06***	0.14***
Community level model	0.07**	0.04**	0.09***
Health facility level model	0.07**	0.03**	0.09**
Individual, household, community, and health facility level model	0.06***	0.03***	0.08***
Variance of the random intercept			
Null model	1.22 (0.04)***	1.12 (0.03)***	1.27 (0.14)***
Individual- and household level model	0.52 (0.05)***	0.47 (0.04)***	0.52 (0.09)***
Community level model	0.34 (0.05)***	0.39 (0.04)***	0.32 (0.06)***
Health facility level model	0.32 (0.05)***	0.34 (0.04)***	0.29 (0.06)***
Individual, household, community, and health facility level model	0.29 (0.06)***	0.31 (0.05)***	0.28 (0.07)***

Notes.
***$P < 0.01$, **$P < 0.05$, *$P < 0.1$.
[a] The ICC is a ratio of the cluster level variance to the total variance, Full model results are presented in Table 4 and Supplementary Tables 1–3.

increased education of mothers and their partners as compared to uneducated mothers and partners, respectively. As compared with the women with poorer wealth quintile, the aPR of stunting was found to be decreased by 17% (aPR, 0.83, 95% CI, 0.70–0.99) and 32% (aPR, 0.68, 95% CI, 0.54–0.86) among women in the richer and richest wealth quintile, respectively. However, a 32% reduction of aPR of the underweight was found among women in the richest wealth quintile as compared to the poorer women.

Of the considered community-level factors, we found a lower aPR of stunting among children in Dhaka (aPR, 0.81, 95% CI, 0.66–0.99) and a higher aPR of stunting among children in the Sylhet (aPR, 1.22, 95% CI, 1.06–1.42) divisions as compared to the children in the Barishal division. However, around 16–25% lower prevalence of stunting and underweight were found among children in the Rangpur division as compared to the children in the Barishal division. We also found that the prevalence of stunting was increased by 8% (aPR, 1.08, 95% CI, 1.02–1.12) for every kilometer increased distance of the nearest health facility from mothers' homes where child healthcare services are available. Similarly, every kilometer increased in the nearest health facility where children's healthcare services are available from mothers' homes was found to be associated with a 6% increase in the likelihood of wasting (aPR, 1.06, 95% CI, 1.01–1.14).

8. Discussion

In LMICs, including Bangladesh, both child nutritional disorder and SBI are common and ongoing public health problems. There might be a relationship between child nutritional disorder and SBI, that can arise from several biological, social, and behavioural pathways. However, a solid understanding of this is still lacking, particularly in Bangladesh. By analysing the nationally representative household (2017/18 BDHS) and health facility (2017 BHFS) survey data, we filled this gap. We found around 20% and 14% increase in the likelihoods of stunting and underweight, respectively, among children born in the SBI as compared to the children born in the normal interval. The likelihoods of nutritional disorders were also found lower among children of educated parents and higher households' wealth quintile. Moreover, child nutritional disorder was found to be increased with the increased distance of mothers' homes from the nearest healthcare facility where child healthcare services are available. These findings are robust as they are generated by analysing two nationally representative datasets where sophisticated statistical method with a range of confounders at the individual-, households-, community-, and health-facility level is used. Therefore, the findings will help the policy maker in Bangladesh as well as other LMICs to guide appropriate policies and programs.

We found the prevalence of stunting, wasting, and underweight among children born in a short interval was 30%, 22% and 29%, respectively. These are comparatively higher than the corresponding national level prevalence of stunting (31%), wasting (8%), and underweight (22%).[23,29] A comparative figures are observed in some other South Asian countries, including India (stunting, 45.9%; wasting, 17.1%; and underweight, 35.4%), Pakistan (stunting, 44.4%; wasting, 10.7%; and underweight, 29.4%) and Myanmar (stunting, 29.0%; wasting, 7.3%; and underweight, 19.2%).[16,18,21] In 2011, the prevalence of stunting, wasting, and underweight in Bangladesh was 41.3%, 11% and 36.2%, respectively.[3] This decline is mainly due to the policies and programs that were taken to achieve the Millennium Development Goals (2000–2015) and later to achieve the SDGs (2015–2030).[23]

We found the likelihoods of becoming stunted and underweighted were around 14–20% higher among children born in SBI than children born in normal interval. Similar findings have been reported in other LMICs, including India, Pakistan, Myanmar, Nepal, Ethiopia, and Burundi.[16,18,21,30] The reasons for such higher likelihoods of nutritional disorders among children born in SBI than children born in the normal interval are many and they are mostly interconnected. Births in the short interval are mainly occurred because of parents' unawareness about the adverse effect of short interval babies, not use or use of less effective contraception, desire more many children or children of a particular sex or more likely some combination of three.[10] These characteristics are found common among uneducated and lower wealth quintile mothers in Bangladesh as well as other LMICs.[3,10,19–21,27] Importantly, these factors were also found positively associated with child nutritional disorders in this study, as like previous studies in Bangladesh and other LMICs.[3,29] Educated and higher wealth quintile mothers as compared to their non-educated counterparts are comparatively more informed about the nutritional needs of their children.[18,29] Therefore, they tried to ensure their children's nutritional requirements.[18,31] They are also comparatively more informed about communicable diseases, including diarrhea and acute respiratory infection.[23] Therefore, they tried to ensure safe hygiene and food for their children. Together these contribute to a lower prevalence of stunting, wasting, and underweight among children of educated mothers.

Similarly, uneducated, and lower wealth quintile mothers are mostly undernourished in Bangladesh.[32] The underlying reasons are their poor socio-demographic condition, as well as their inadequate diet plan, poor living standards, and financial inability to buy nutrients foods.[32,33] They also have a lack of access to healthcare services.[22] Pregnancy and birth among mothers having these characteristics have several negative consequences, including birth outcomes.[32] The reason is the depletion of the mother's nutrient reserves, which leads to the increased risk of intrauterine growth retardation.[32] This then adversely affects infant nutrient stores at birth and nutrient delivery via breastfeeding.[32,34] Consequently, nutritional disorders have occurred. These mothers' characteristics are added to the challenges that arise because of SBI. For instance, the occurrence of two births in a SBI can reduce the amount of time that the mother can dedicate to the older child due to caring for the new infant as well as divide limited available foods among two children.[35] This is particularly an issue for the children in the poor wealth quintile where mothers may divide limited foods among their two closely distanced children.[29] These further affect the nutritional status of the current child.

At the divisional level, the likelihoods of stunting and underweight

Table 4
Multilevel Poisson regression examining the association stunting and short birth interval adjusting with individual, household and community level factors.

Characteristics	Stunting [Individual-, household-, community, health facility level model], PR (95% CI)	Wasting [Individual-, household-, community, health facility level model], PR (95% CI)	Underweight [Individual-, household-, community, health facility level model], PR (95% CI)
Birth interval			
Not in short birth interval (ref)	1.00	1.00	1.00
Short birth interval	1.20 (1.08–1.33)*	0.81 (0.63–1.04)	1.14 (1.01–1.30)*
Maternal age at birth			
≤19 (ref)	1.00	1.00	1.00
20-34	1.01 (0.85–1.21)	1.02 (0.69–1.51)	0.95 (0.76–1.20)
≥35	1.02 (0.78–1.32)	1.01 (0.55–1.86)	1.05 (0.75–1.46)
Maternal age at first birth	0.95 (0.85–1.07)	0.81 (0.61–1.06)	0.96 (0.84–1.11)
Mother's educational status			
No education (ref)	1.00	1.00	1.00
Primary	0.95 (0.82–1.10)	0.68 (0.48–0.95)	0.79 (0.66–0.94)*
Secondary	0.90 (0.76–1.07)	0.69 (0.49–0.99)	0.74 (0.61–0.90)*
Higher	0.59 (0.43–0.81)*	0.58 (0.33–1.02)	0.53 (0.37–0.75)*
Mothers' formal employment			
No (ref)	1.00	1.00	1.00
Yes	1.09 (0.99–1.21)	0.97 (0.78–1.21)	1.12 (0.98–1.25)
Mothers' partners educational status			
No education (ref)	1.00	1.00	1.00
Primary	0.93 (0.83–1.03)	0.96 (0.71–1.30)	0.92 (0.80–1.06)
Secondary	0.79 (0.69–0.91)*	1.13 (0.80–1.60)	0.90 (0.76–1.07)
Higher	0.71 (0.56–0.90)*	0.84 (0.52–1.36)	0.79 (0.61–1.03)
Sex of the household's head			
Male (ref)	1.00	1.00	1.00
Female	0.95 (0.83–1.08)	0.92 (0.67–1.25)	0.81 (0.68–0.98)*
Total children ever born			
≤2 (ref)	1.00	1.00	1.00
>2	1.06 (0.95–1.19)	0.92 (0.66–1.25)	1.08 (0.95–1.23)
Exposure to mass media			
Little exposed (ref)	1.00	1.00	1.00
Moderately exposed	0.92 (0.79–1.07)	0.95 (0.72–1.26)	0.95 (0.79–1.15)
Highly exposed	0.90 (0.80–1.00)	1.17 (0.85–1.60)	0.90 (0.77–1.05)
Sibling's survival status			
Yes (ref)	1.00	1.00	1.00
No	1.16 (0.99–1.36)	1.01 (0.67–1.53)	0.97 (0.79–1.19)
Wealth quintile			
Poorer (ref)	1.00	1.00	1.00
Poorest	0.98 (0.86–1.12)	1.24 (0.90–1.70)	0.99 (0.85–1.15)
Middle	0.92 (0.80–1.06)	0.95 (0.67–1.33)	0.88 (0.73–1.06)
Richer	0.83 (0.70–0.99)*	1.12 (0.77–1.62)	0.91 (0.75–1.11)
Richest	0.68 (0.54–0.86)*	0.91 (0.55–1.48)	0.68 (0.52–0.89)*
Type of residential place			
Urban (ref)	1.00	1.00	1.00
Rural	1.07 (0.93–1.24)	0.86 (0.64–1.16)	0.97 (0.82–1.16)
Division			
Barishal (ref)	1.00	1.00	1.00
Chattogram	1.06 (0.89–1.25)	0.86 (0.61–1.28)	0.96 (0.77–1.20)
Dhaka	0.81 (0.66–0.99)*	1.03 (0.70–1.53)	0.83 (0.64–1.08)
Khulna	0.86 (0.70–1.06)	0.87 (0.56–1.35)	0.78 (0.59–1.03)
Mymensingh	1.01 (0.85–1.20)	1.02 (0.70–1.48)	0.95 (0.77–1.18)
Rajshahi	0.88 (0.72–1.07)	0.83 (0.54–1.28)	0.93 (0.72–1.20)
Rangpur	0.84 (0.71–0.99)*	0.69 (0.45–1.06)	0.75 (0.60–0.95)*
Sylhet	1.22 (1.05–1.42)*	1.14 (0.80–1.63)	1.23 (1.01–1.50)*
Community level literacy			
<21.0 (Low) (ref)	1.00	1.00	1.00
21.0–50.0 (Moderate)	0.98 (0.88–1.09)	0.93 (0.72–1.19)	1.06 (0.91–1.23)
>50.0 (High)	1.03 (0.88–1.21)	0.95 (0.68–1.34)	1.22 (0.99–1.52)
Community level poverty			
>41.0 (High poverty) (ref)	1.00	1.00	1.00
16.0–41.0 (Moderate poverty)	0.97 (0.84–1.13)	1.02 (0.75–1.38)	1.11 (0.94–1.32)
≤15.0 (Low poverty)	1.05 (0.86–1.29)	0.85 (0.50–1.45)	1.03 (0.77–1.36)
Middle and richest community	1.20 (0.94–1.52)	1.09 (0.70–1.71)	1.08 (0.81–1.44)
Community level fertility			
≤2.10 (Low) (ref)	1.00	1.00	1.00
>2.10 (High)	0.94 (0.83–1.06)	0.98 (0.76–1.25)	0.93 (0.79–1.08)
Average distance to the nearest health facility	1.08 (1.02–1.12)**	1.06 (1.01–1.14)**	1.13 (0.99–1.26)

Note: *p < 0.05, ***p < 0.01. Model summary for each model is presented in Table 3; Full model results for each outcome are presented in the Supplementary file [Supplementary Table 1 to Supplementary Table 3].

were found higher among children in the Sylhet division and lower in the Rangpur division. Previous studies in Bangladesh also reported a similar finding.[3,29] These differences are linked with the regional level variations of socio-demographic status including the mother's education and occupation as well as the prevalence of SBI.[29,36] Sylhet division in Bangladesh is mostly covered with Haor areas where the people are mostly uneducated and depend on either fishing or cultivating, or both.[36] A significant portion of the Sylhet division is also covered by the tea gardens, which are mostly separated from the mainstream community with very lower income and healthcare services use. Each of these divisional level characteristics could be linked with the higher likelihood of nutritional disorders among children in the Sylhet division, as found in this study. In comparison, the Rangpur division is mostly a land area and the socio-demographic characteristics of the people residing in this region are different from the Sylhet division, including the prevalence of secondary to higher education and higher use of healthcare services.[23] The prevalence of SBI is also lower in this division.[10,36] These could be linked to the lower prevalence of nutritional disorders among children born in the Rangpur division as found in this study.

In this study, we also found that increased distance between the mothers' homes and the nearest healthcare facility is associated with the increasing likelihood of nutritional disorders. This linkage may arise because increased distance reduces healthcare services access to the mothers as well as their children.[22] This might lead to a higher occurrence of poor birth outcomes and a higher prevalence of communicable diseases, including diarrhea.[23] These factors are found linked to the higher prevalence of child nutritional disorders in previous studies in LMICs.[3,19–21] Importantly, this could be an important pathway of the regional level variations in the likelihood of child nutritional disorders which is reported in this study. Our study finding of a higher prevalence of nutritional disorders among children in the Sylhet region, where the average distance between home and healthcare facility is comparatively higher as compared to the other regions of Bangladesh, is supportive of this conclusion.[10]

This study has several strengths and a few limitations that should be acknowledged. The main strength of the study is the use of nationally representative data with considerable large sample size. We categorised the outcome and exposure variables as per the WHO guidelines. Moreover, we used sophisticated statistical analysis and considered a wide range of confounding factors at the individual-, household-, community-, and health facility levels. Consequently, the findings of this study are robust and should be used in making national level policies and programs. However, as this study is based on the analysis of cross-sectional survey data, therefore, the associations reported were correlational only, not causal. The information in the survey was also recorded retrospectively with no scope of validation. This might be the cause of recall bias and reporting errors. However, any such errors is likely to be random. Moreover, other than the factors considered in this study, environmental factors and the occurrence of communicable diseases are important causes of occurring child nutritional disorders. Therefore, it is important to adjust them in the models. However, we could not do that because of the lack of relevant data.

9. Conclusion

The reported prevalence of SBI was around 26% and stunting, wasting, and underweight among children born in SBI were 30%, 22% and 29%, respectively. The likelihoods of becoming stunted and underweighted were found 14–20% higher among children born in a shorter interval as compared to the children born in a normal interval. This indicates a potential challenge for Bangladesh to improve child health. Consequently, targeted interventions to increase birth intervals through rising family planning services and contraceptive methods are important. Additional policies and programs should be taken to improve mothers' and their partners' educational level and households' wealth quintile as well as raise awareness about the adverse effect of births in a shorter interval on child nutritional disorders. Increasing the availability of healthcare services at the community level through rising the number of healthcare facilities should also be considered.

Ethical statement

This study analysed secondary data publicly available. Ethical approval for this survey was provided by the Bangladesh Medical research counsel and Demographic and Health Survey Program of the USA. No additional ethical approval is required to conduct this study.

Funding

The authors did not receive any fund for this study.

Authors' contributions

MZI and MNK designed the study, performed the data analysis, and wrote the first draft of this manuscript. MMR critically reviewed and edited the previous versions of this manuscript. All authors approved this final version of the manuscript.

Human and animal right

No animals were used for this study. All human procedure were in accordance with the ethical standard of the ethical approval broad.

Consent for publication

Informed written consent was obtained from all participants.

Availability of data and materials

The Demography and Health Survey (DHS) program of the USA is the custodian of 2017 BDHS data. It is freely available for the user upon submission reasonable request to the DHS.

Declaration of competing interest

The authors have no conflict of interest to disclose.

Acknowledgement

The authors thank the MEASURE DHS for granting access to the 2017/18 BDHS data.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.cegh.2023.101256.

References

1 *WHO. Fact Sheets - Malnutrition*. Geneva, Switzarland: World Health Organization; 2022.
2 Organization WH. *More than One in Three Low-And Middle-Income Countries Face Both Extremes of Malnutrition*. Geneva: WHO; 2019.
3 Chowdhury MRK, Rahman MS, Khan MMH, Mondal MNI, Rahman MM, Billah B. Risk factors for child malnutrition in Bangladesh: a multilevel analysis of a nationwide population-based survey. *J Pediatr*. 2016;172:194–201. e191.
4 Winichagoon P, Margetts BM. The double burden of malnutrition in low-and middle-income countries. *Energy Bal. Obes.* 2017;12(1):9–24.
5 Caulfield LE, de Onis M, Blössner M, Black RE. Undernutrition as an underlying cause of child deaths associated with diarrhea, pneumonia, malaria, and measles. *Am J Clin Nutr*. 2004;80:193–198.
6 Ekirapa-Kiracho E, De Broucker G, Ssebagereka A, et al. The economic burden of pneumonia in children under five in Uganda. *Vaccine X*. 2021;8, 100095.
7 Grantham-McGregor S, Cheung YB, Cueto S, et al. Developmental potential in the first 5 years for children in developing countries. *The lancet*. 2007;369:60–70.

8 *WHO. Child Mortality (Under 5 Years)*. Geneva, Switzarland: World Health Organization; 2020.
9 Paulson KR, Kamath AM, Alam T, et al. Global, regional, and national progress towards Sustainable Development Goal 3.2 for neonatal and child health: all-cause and cause-specific mortality findings from the Global Burden of Disease Study 2019. *Lancet*. 2021;398:870–905.
10 Islam MZ, Islam MM, Rahman MM, Khan MN. Prevalence and risk factors of short birth interval in Bangladesh: evidence from the linked data of population and health facility survey. *PLOS Global Public Health*. 2022;2, e0000288.
11 Egata G, Berhane Y, Worku A. Predictors of acute undernutrition among children aged 6 to 36 months in east rural Ethiopia: a community based nested case-control study. *BMC Pediatr*. 2014;14:1–10.
12 Ekholuenetale M, Tudeme G, Onikan A, Ekholuenetale CE. Socioeconomic inequalities in hidden hunger, undernutrition, and overweight among under-five children in 35 sub-Saharan Africa countries. *J Egypt Publ Health Assoc*. 2020;95:1–15.
13 Gribble JN, Murray NJ, Menotti EP. Reconsidering childhood undernutrition: can birth spacing make a difference? An analysis of the 2002–2003 El Salvador National Family Health Survey. *Matern Child Nutr*. 2009;5:49–63.
14 Ntenda PAM, Chuang Y-C. Analysis of individual-level and community-level effects on childhood undernutrition in Malawi. *Pediatrics & Neonatology*. 2018;59:380–389.
15 Pimentel J, Ansari U, Omer K, et al. Factors associated with short birth interval in low-and middle-income countries: a systematic review. *BMC Pregnancy Childbirth*. 2020;20:1–17.
16 Kang Y, Kim J. Risk factors for undernutrition among children 0–59 months of age in Myanmar. *Matern Child Nutr*. 2019;15, e12821.
17 Chungkham HS, Sahoo H, Marbaniang SP. Birth interval and childhood undernutrition: evidence from a large scale survey in India. *Clinical Epidemiology and Global Health*. 2020;8:1189–1194.
18 Khan S, Zaheer S, Safdar NF. Determinants of stunting, underweight and wasting among children< 5 years of age: evidence from 2012-2013 Pakistan demographic and health survey. *BMC Publ Health*. 2019;19:1–15.
19 Khanam M, Shimul SN, Sarker AR. Individual-, household-, and community-level determinants of childhood undernutrition in Bangladesh. *Health services research and managerial epidemiology*. 2019;6, 2333392819876555.
20 Khokan MR. The effects of birth spacing on nutritional status in the form of stunting of under five children in Bangladesh: evidence based on BDHS, 2014 data. *Dhaka University Journal of Science*. 2019;67:139–144.
21 Murarkar S, Gothankar J, Doke P, et al. Prevalence and determinants of undernutrition among under-five children residing in urban slums and rural area, Maharashtra, India: a community-based cross-sectional study. *BMC Publ Health*. 2020;20:1–9.
22 Wb B. *Health Facility Survey 2017*. 2020.
23 Niprot MaA, ICF. Bangladesh Demographic and Health Survey 2017-18. National Institute of Population Research and Training, Metra and Associates, and ICF International, Dhaka, Bangladesh.
24 Woldeamanuel BT. *Socioeconomic, Demographic, and Environmental Determinants of Under-5 Mortality in Ethiopia: Evidence from Ethiopian Demographic and Health Survey, 2016*. Child Development Research; 2019, 2019.
25 Corsi DJ, Perkins JM, Subramanian S. Child anthropometry data quality from demographic and health surveys, multiple indicator cluster surveys, and national nutrition surveys in the west central africa region: are we comparing apples and oranges? *Glob Health Action*. 2017;10, 1328185.
26 Organization WH. *Report of a WHO Technical Consultation on Birth Spacing: Geneva, Switzerland 13-15 June 2005*. World Health Organization; 2007.
27 Khan MN, Harris M, Loxton D. Modern contraceptive use following an unplanned birth in Bangladesh: an analysis of national survey data. *Int Perspect Sex Reprod Health*. 2020;46:77–87.
28 Kroeger A. Anthropological and socio-medical health care research in developing countries. *Soc Sci Med*. 1983;17:147–161.
29 Chowdhury MRK, Khan HT, Rashid M, et al. Differences in risk factors associated with single and multiple concurrent forms of undernutrition (stunting, wasting or underweight) among children under 5 in Bangladesh: a nationally representative cross-sectional study. *BMJ Open*. 2021;11, e052814.
30 Tiwari R, Ausman LM, Agho KE. Determinants of stunting and severe stunting among under-fives: evidence from the 2011 Nepal Demographic and Health Survey. *BMC Pediatr*. 2014;14:1–15.
31 Alderman H, Headey DD. How important is parental education for child nutrition? *World Dev*. 2017;94:448–464.
32 Khan MN, Rahman MM, Shariff AA, Rahman MM, Rahman MS, Rahman MA. Maternal undernutrition and excessive body weight and risk of birth and health outcomes. *Arch Publ Health*. 2017;75:1–10.
33 Khan MN, Mondal MNI, Islam MR, Al-Mamun M, Shitan M. Trends in body mass index and its determinants among ever-married non-pregnant women in Bangladesh. *Malaysian Journal of Nutrition*. 2015;21.
34 Triunfo S, Lanzone A. Impact of maternal under nutrition on obstetric outcomes. *J Endocrinol Invest*. 2015;38:31–38.
35 Islam MZBM, Islam MM, Rahman MM, Khan MN. Negative effects of short birth interval on child mortality in low- and middle-income countries: a systematic review and meta-analysis. *Journal of Global Health*. 2022;2022:1–22.
36 Islam MZ, Islam MM, Rahman M, Khan M. Exploring hot spots of short birth intervals and associated factors using a nationally representative survey in Bangladesh. *Sci Rep*. 2022;12:1–10.