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Original Article

Small size at birth as a predictor of increased risk of childhood morbidity, mortality and malnutrition: Evidence from Bangladesh demographic and health survey

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ABSTRACT

Background & Aim: Physical size or weight at birth of an infant is an important biomarker of current and future health and development of the infant. The aim of this study is to examine the effect of small size at birth – a proxy indicator of low birth weight - on childhood mortality, morbidity and malnutrition in Bangladesh.

Methods & Materials: The data for the study come from the 2014 Bangladesh Demographic and Health Survey. A total of 4,897 live births with information on size at birth as reported by their mothers were included in the analysis. Both descriptive and multivariate statistical techniques were used for data analysis

Results: One in every five live births (20%) was reported to be small in size in Bangladesh. Children born with small size at birth have some distinct characteristics than average size babies. Significantly higher incidence of malnutrition, mortality and morbidity were found among small size babies compared to average size babies. The multivariate analysis identified small size at birth as a significant predictor of childhood malnutrition, mortality and morbidity from diarrhea. Small size infants had 1.6 to 2.2 times higher risk of stunting, wasting or underweight, 1.6 times higher risk of diarrhea and 2.4 times higher risk of death during neonatal period than average size infants.

Conclusion: Health education to parents and special care for small size babies through trained health workers need to be undertaken for improving the health of small size babies. At the same time, appropriate policy should be taken to reduce the incidence of small size babies.

Introduction

Low birth weight (LBW), defined as weight at birth less than 2,500 g (1), has long been identified as a key predictor of morbidity, mortality, malnutrition as well as physical, emotional, psychological, and scholastic development and well-being in childhood and for the rest of life (2-5). Studies have shown that LBW babies are 20 times more likely to die during infancy than the normal weight (≥ 2500 g) babies (2, 3). Like infant mortality, LBW weights were found to have strong association with infant morbidity (6, 7). Acute respiratory tract infections (ARIs) were found to be more common among infants with LBW (8). LBW infants have a higher prevalence of cough and worse lung function than infants with normal birth weight in their early and later childhood (9). Malnutrition is more common among LBW infants than their normal weight counterparts and it predisposes LBW babies to significant metabolic maladaptation, growth failure, and long-term neurological injury (10). The study of global burden of diseases demonstrated LBW as the leading cause of death and disability among newborn babies (11). Although it has been estimated that 15-20% of all births worldwide are LBW, representing more than 20 million births a year, they account for 60–80% of neonatal deaths worldwide (12).

It has been observed that 96% of LBW infants live in developing countries, and the incidence of LBW in developing countries (17%) is more than double the incidence in developed regions (7%)

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(4). Half of these LBW babies are born in south-central Asia, where more than 27% of all births are less than 2.500 grams (4). The problem of LBW babies is more serious in India, Bangladesh and other South East Asian countries. It was estimated that about 28% of all newborns in this region are LBW babies (13).

Although, Bangladesh has made considerable progress towards improving survival probabilities for children and reducing malnutrition levels, childhood morbidity, mortality and malnutrition rate still very high by any standard. Diarrhea, acute respiratory infections (ARI), and fever are the major childhood morbidity and causes of childhood mortality in Bangladesh (14). Previous studies, mostly based on hospital and regional data, demonstrated that Bangladesh has one of the highest incidences of LBW in the world (15, 16). According to the 2003-2004 National Low Birth Weight Survey in Bangladesh, the incidence of LBW was 36% (17). This high rate of LBW might be linked with the high rate of childhood mortality, morbidity and malnutrition in Bangladesh.

As birth weight constitutes a good indicator of the current health status of the children and a good predictor of their future health problems, accurate knowledge about birth weight and its determinants could help develop a better evidence based intervention program for the health, nutrition and survival of infants and reduce childhood mortality and morbidity in Bangladesh. However, very little or no attention has been paid to the relationship between LBW and child health and survival in Bangladesh due to limited or non-availability of accurate data on birth weight.

In Bangladesh, most deliveries (63%) take place at home and are mostly (58%) attended by traditional birth attendants, relatives or friends (18). Thus birth weights of a vast majority of the new born babies in the country are unknown. Even if babies are weighed at birth when deliveries took place in health facilities, their weights are not always measured accurately, or recorded and reported correctly (4). However, a very limited data on birth weight are available for those babies born in hospital or clinics in Bangladesh. But these hospital or clinic based data on birth weight suffer from selection bias, because a selective group of people only go for delivery in health facilities, and thus have limited use (19, 20). The similar situation exists in all other developing countries around the world where most of the deliveries occur outside health facilities. Under these circumstances, Bangladesh and other developing countries are facing difficulties in screening LBW and providing appropriate care and services for the LBW babies. Thus, it is necessary to develop an alternative measure that can be used as a proxy indicator for LBW in Bangladesh and elsewhere.

Recently, researchers are increasingly advocating that in the absence of reliable data on birth weight (BW), data on physical size of the baby that can easily be obtained through survey can be used as a proxy indicator of birth weight (21-24). Although a mother may be ignorant of the actual birth weight of her baby or have difficulty in recalling it at the time of survey, but she can easily recall the size of her baby. In fact, the worldwide Demographic and Health Surveys (DHSs) and Multiple Indicator Cluster Surveys (MICSs) are increasingly using the question on physical size of the infant at birth as a proxy for birth weight in many developing countries (21-25). In these surveys, mothers are asked to classify their babies according to their sizes, ranging from very small to very large. Some studies have shown that there is a good consistency between recalled size at birth and birth weight on an aggregate level and concluded that mothers' reported birth size as very small or smaller than average can be used as a reasonably good indicator of LBW at the aggregate level (20-24, 26).

In this study, an attempt has been made to use physical size of babies at the time of birth, obtained through recent Bangladesh Demographic and Health Survey (BDHS), as a proxy measure of birth weight. As mentioned earlier, a mother's report of a child being "very small" or "smaller than average", can be considered as a useful proxy for LBW. Thus the objective of this study is to examine the effect of small size at birth of infants on their childhood mortality, morbidity and nutrition in Bangladesh. We hypothesized that small size at birth is associated with the increased risk of childhood morbidity, morbidity and malnutrition. This type of study is rare in the literature and first of its kind in Bangladesh. The findings of the study may have important policy implications for child health care program in Bangladesh and elsewhere.

Methods

The Data

The data for the study come from the 2014 *Bangladesh Demographic and Health Survey* (BDHS). The survey was implemented through a collaborative effort of National Institute of Population Research and Training (NIPORT) of the Ministry of Health and Family Welfare (MoHFW) of Bangladesh, with the technical and financial support provided by the United States Agency for International Development (USAID)/Dhaka. The survey covered a nationally representative sample of 17,683 ever-married women aged 15-49 years from 17,300 households. The sample households were selected on the basis of a two-stage stratified cluster sampling design to provide statistically reliable estimates of key demographic and health variables for the country as a whole, for urban and rural areas separately, and for each of the seven administrative divisions namely Barisal, Chittagong, Dhaka, Khulna, Rajshahi, Rongpur, and Sylhet. The detailed of the survey is available in NIPORT et al. (18).

Our analysis was based on data related to children born in the 5 years before the survey date for whom the information on size at birth according to their mothers' estimate were available. The survey gives complete information for children with regard to their health, parental, household and community characteristics.

Outcome and explanatory variables

The study considered three sets of outcome variables, namely mortality, morbidity and nutritional status of the children. For mortality, the outcome variables are cohort probabilities of death based on survival status and age at death for children who have had full exposure to dying during the given age ranges of mortality. Depending on age at death, mortality rates were categorized as neonatal (<1 months), post neonatal (1-11 months), infants (0-11 months) and under-five (0-59 months) mortality rates.

For morbidity, we have considered three major childhood illness – diarrhea, acute respiratory infection (ARI) and fever – as outcome variables. The morbidity data contained in the survey come from the mother's responses to questions on recent episodes of diarrhea, ARI and fever. Mothers were asked if their child had diarrhea, cough with short rapid breaths or fever in the 2 weeks preceding the survey. All the morbidity related variables were dichotomized by coding mother's 'yes' response to the child suffering from diarrhea, ARI or fever as '1' while a 'no' response was coded '0'.

For nutritional status, the outcome variable is the percent of young children who are stunted, wasted, or who are underweight. As part of the interviewing procedure, the BDHS surveys routinely collect the height and weight of children under age 5 years. Together with the child's age, this information can be used to assess the nutritional status of children when compared to a reference standard using standard deviation values (z-scores). The BDHS data were compared to the NCHS/CDC/WHO international reference standards for height-for-age, weight-for-age, and weight-for-height. Children whose z-scores were less than two standard deviations below the mean (-2 SD) on the reference standard were considered moderately or severely malnourished. Chronic malnutrition or stunting was determined by a height-for-age z-score below two standard deviations below the mean. Acute malnutrition or wasting was measured by a z-score less than -2 SD for weight for height, and overall malnutrition or underweight was measured by a z-score less than -2 SD for weight for age.

Birth size was our key explanatory variable in the study. In the 2014 BDHS no effort has been made to collect birth weight data. However, the survey collected mother's perceived size of their babies at the time of birth. Data on infant's size at birth was obtained by asking mothers: When (NAME) was born, was he/she; very large, larger than average, average, smaller than average, or very small? Thus, in the absence of birth weight data in the 2014 BDHS, we used mother's recall of size at birth of their infants born in last five years before survey date as the proxy measure of birth weight. We created a binary outcome variable: *'small size'* and '*average or larger than average size'*. Smaller than average and very small sized babies were termed as small size and very large, larger than average and average sized babies were termed as average or larger than average size.

Statistical analysis

The analysis involved a number of stages. The first stage was a descriptive analysis to examine the characteristics of the sample and to estimate the proportion of children by their size at birth. The second stage was to estimate childhood mortality rates, prevalence of morbidity due to diarrhea, ARI or fever and nutritional status by size at birth of all live births that occurred in five years before survey date, and examined the bivariate association between different measures of childhood mortality, morbidity or nutritional status and size at birth of children. The bivariate association between small size at birth and the explanatory variables of interest was first evaluated by using Chi-square test (χ^2). A p-value less than 0.05 was considered as statistically significant. The third stage involved multivariate analysis to examine the effect of small size at birth on childhood mortality, morbidity or nutritional status after controlling the effects of socio-economic and demographic factors. The socio-economic and demographic factors included maternal age at birth of child, mother's education, mother's BMI, child's sex, birth order, rural/urban residence, region of residence and wealth index. The wealth index is a composite indicator of the economic status of the family which is used by the DHS surveys globally (27).

Depending on the nature of dependent variables, multivariate analyses were done by using proportional hazard and logistic regression models. Since the childhood mortality rates are time dependent variable involving censored cases (as not all children had the chance to survive to the oldest age under investigation by the time of the interview and thus had right-censored), we used Cox's proportional hazard model in the multivariate analysis to account for right-censoring. To examine the association between small size at birth (measured as very small or small) and the risk of dying during neonatal, post-neonatal, infant and under five years of age period, we used a proportional hazard model with a piecewise constant baseline hazard by dividing the child's first five years into four exposure periods (0-1 months, 1-11 months, 0-11 months and 0-59 months) and assuming that the baseline hazard is constant within each period. On the other hands, as the childhood morbidity measures (i.e. having or not having diarrhea, ARI or fever in last 2 weeks before survey date) and nutritional status such as stunting, wasting or underweight are binary in nature, we used logistic regression model in the multivariate analysis to examine their association with small size at birth after controlling the effects of potential confounders.

Results

Distribution of size at birth

According to the 2014 BDHS, there were 4,897 infants with information about their size at birth. The distribution of these infants by their size at birth as perceived by their mothers indicates that about 7% of live births were perceived to be very small in size by the mothers, and another 13% as smaller than average in size (Table 1). Overall, 20% (95% CI: 19.0% - 21.0%) of the live births can be termed as "small in size" or LBW babies and the rest 80% as "average or more than average size" or normal weight babies. In the rest of the text we will term them as "small size" and "average size" babies.

Sample Characteristics

Table 2 summarizes the sample characteristics along with a comparative analysis of the characteristics of small size and average size babies across a set of socio-economic and demographic variables. Most of the children (84%) were born to young mothers of age less than 30 years. About 4% of the children were born to mothers with advanced age of 35 years. The average age of mothers at the time of birth of the children was 23.6 years. Most of the mothers had primary (28%) or secondary (48%) education and a small proportion (10%) had higher than secondary education. About 40% of the children were the first born. Slightly more than half (53%) of the children were male. One-fifth (21%) of mothers never attended to any antenatal care (ANC) visits and 31% had 4 or more ANC visits. Most of the children (60%) were born to mothers with normal BMI (18.5-24.9). Almost three-fourth (74%) of the children was from rural areas. More than half (57%) of the children occurred

Table 1. Percent distribution of live births in the five years preceding the survey by mother's estimate of baby's size at birth, Bangladesh 2014

Size at birth	Number	Percentage
Very small	332	6.8
Smaller than average	646	13.2
Average	3,304	67.5
larger than average	509	10.4
Very large	106	2.2
Small	978	20.0
≥ Average	3,919	80.0
Total	4,897	100.0

Table 2. Percent distribution of live births in the five years preceding the survey by size at birth (small or ≥ average), according to background characteristics, BDHS 2014

Factors	Size at Birth			All births	
	Small	≥ Average	Total	Number	%
Mother's age at birth of child**					
< 20	21.9	78.1	100.0	1,370	27.98
20-29	18.8	81.2	100.0	2,752	56.20
30-34	18.1	81.9	100.0	559	11.42
35+	27.3	72.7	100.0	216	4.41
Mothers education***					
No education	26.5	73.5	100.0	701	14.31
Primary	21.1	78.9	100.0	1,376	28.10
Secondary	18.5	81.5	100.0	2,330	47.58
Higher	14.3	85.7	100.0	490	10.01
Parity ***					
1	21.0	79.0	100.0	1,977	40.37
2	18.9	81.1	100.0	1,470	30.02
3	15.8	84.2	100.0	780	15.93
4+	24.0	76.0	100.0	670	13.68
Children gender					
Male	17.8	82.2	100.0	2,575	52.58
Female	22.4	77.6	100.0	2,322	47.42
Number of ANC visit***					
0	25.6	74.4	100.0	991	21.45
1-3	18.7	81.3	100.0	2187	47.34
4+	17.8	82.2	100.0	1442	31.21
Mother's BMI***					
< 18.5	24.9	75.1	100.0	1,165	24.00
18.5-24.9	19.1	80.9	100.0	2,888	59.50
≥25.0	15.5	84.5	100.0	801	16.50
Region***					
Barisal	17.3	82.7	100.0	278	5.68
Chittagong	21.8	78.2	100.0	1,074	21.93
Dhaka	21.0	79.0	100.0	1,739	35.51
Khulna	18.1	81.9	100.0	386	7.88
Rajshahi	15.4	84.6	100.0	488	9.97
Rangpur	13.4	86.6	100.0	461	9.41
Sylhet	26.1	73.9	100.0	471	9.62
Place of residence					
Urban	18.7	81.3	100.0	1,265	25.83
Rural	20.4	79.6	100.0	3,632	74.17
Wealth index***					
Poorest	23.8	76.2	100.0	1,082	22.10
Poorer	20.5	79.5	100.0	932	19.03
Middle	19.7	80.3	100.0	939	19.18
Richer	18.9	81.1	100.0	996	20.34
Richest	16.5	83.5	100.0	948	19.36
Total					

Note: The number of missing values may vary for each variable. The percentages presented are valid percentages.
**p<0.05; ***p<0.001

from the two most populous regions namely Dhaka and Chittagong.

Small size infants have many distinct characteristics than the average size infants. Small size infants were more likely to occur among young mothers of age less than 20 years and among mothers of advanced age of 35 years and above, indicating a U-shaped pattern of relationship between maternal age and small size infant. Like maternal age, maternal parity also showed similar U-shaped pattern of relationship with small size of infants (Table 2). Small size babies were found to be more common among mothers with no education or primary level of education than normal size babies. Small size babies are more likely to be female than male. The incidence of small size infants is likely to be higher among mothers with no antenatal care (ANC) visits. Small size infants were more likely to be associated with mothers having underweight (i.e. BMI < 18.5). Infants from Sylhet division were found to be more likely to have small size than other divisions. Small size babies are more likely to occur among mothers with poorest wealth status and living in rural areas. The results in Table 2 indicate that all the selected socio-economic and demographic factors, except urban/rural place of residence have significant association with size of babies at birth.

Size at birth and childhood malnutrition

Table 3 shows the percentage of children under age 5 years classified as malnourished according to height-for-age (stunting), weight-for-height (wasting), and weight-for-age (underweight) indices, by size at birth of children. The data show that overall more than one-third (36%) of children under 5 years of age were short for their age or stunted. The prevalence of stunting was significantly higher among the children with small size at birth than the children with average size at birth (44.6 Vs. 30.5%, $p<.005$). Overall, 14 percent of the children were wasted or too thin for their height. The data indicate that children with small size at birth had almost two times higher risk of being wasted than the children with average size at birth (23.3 Vs. 12.8%, $p<0.001$). The overall prevalence of underweight was found to be 32%. The prevalence of underweight also found to be significantly higher among the children with small size at birth than the children with average size at birth (47 Vs. 26%, $p<0.001$). The results thus indicate that size at birth is a strong predictor of nutritional status of children.

Size at birth and childhood morbidity

Table 4 presents the percentage of children under age 5 who had a recent episode of diarrhea, acute respiratory infection (ARI) and fever during the two weeks preceding the survey. Overall, about 36% of the children under age 5 had a fever in the two weeks before the survey. Size at birth of children shows strong differential effect on the prevalence of fever among the children. The prevalence of fever was found to be significantly higher among the children with small size at birth than the children with average size at birth (43% Vs. 33%, $p< 0.005$). About 6 percent of children under age 5 were reported to have had diarrhea. The prevalence of diarrhea was significantly higher among the children with small size at birth than the children with average size at birth (7.2 vs. 4.2%, $p<0.05$). Overall, 5.6% children under age 5 had symptom of ARI. The prevalence of ARI was found to be higher among the children with small size at birth than the children with average size at birth. However, the difference

Table 3. Percentage of children under age 5 according to nutritional status (stunting, wasting, underweight) by size at birth, Bangladesh 2014

Nutritional indicators	Birth size		Over all	P-value	Number of children
	Small	≥ Average			
Children Stunted				0.002	
Yes	44.6	30.5	35.8		1,556
No	55.4	69.5	64.2		2,790
Children Wasted				0.000	
Yes	23.3	12.8	14.2		617
No	77.7	87.2	85.8		3,729
Children Underweight				0.000	
Yes	47.1	25.8	31.5		1,369
No	52.9	74.2	68.5		2,976

Note: The number of missing values may vary for each variable. The percentages presented are valid percentages.

Table 4. Percentage of children under age 5 according to morbidity status (fever, diarrhea, ARI) by size at birth, Bangladesh 2014

Morbidity indicators	Birth size		Over all	P-value	Number of children
	Small	≥ Average			
Children had fever				0.001	
Yes	43.1	32.6	35.6		1,742
No	56.9	67.4	64.4		3,152
Children had diarrhea				0.012	
Yes	7.2	4.2	5.8		284
No	92.8	95.8	94.2		4,610
Children had ARI†				0.144	
Yes	6.2	4.8	5.6		304
No	93.8	95.2	94.6		4,591

Note: The number of missing values may vary for each variable. The percentages presented are valid percentages.
† Symptom with cough accompanied by short, rapid breathing that was chest-related and/or by difficult breathing that was chest-related is considered as ARI.

was not statistically significant.

Size at birth and childhood mortality

Out of 4,897 live births considered in this study, 225 were recorded as dead during their childhood (i.e. aged 0-59 months) (Table 5). Thus the overall mortality rate was observed to be 46 deaths per 1000 live births under age 5 years. The corresponding rates for children with small size at birth and for children with average size at birth were observed to be 68/1000 live births and 41/1000 live births, respectively. The difference is statistically significant. This indicates that children with small size at birth have 1.7 times higher mortality rate during childhood than that of children with average size at birth. It is to be noted that small size babies constituted 20% of the total live births, whereas deaths of small size babies constituted bout 68% of the total deaths of the children during first five years of age.

Table 5 also presents the neonatal, post-neonatal and infant mortality rates among children with small size at birth and with average size at birth. The results indicate that the mortality rates of children with small size at birth were significantly higher than the mortality rates of children with average size at birth in all age ranges under the age of 5 years. For example, the infant mortality rate (IMR) was 66 deaths per 1000 live births among small size babies as oppose to 30 deaths per 1000 live births among average size babies. This indicates that infant mortality rate was 2.2 times higher among small size babies than that of average size babies. The effect of small size at birth on mortality even higher during neonatal period.

Risk of childhood morbidity, mortality and malnutrition for small size at birth: Multivariate analysis

The foregoing bivariate analysis indicates that small size at birth of children increase the risk of childhood malnutrition, morbidity and mortality. However, bivariate analysis provides unadjusted risk without controlling the effect of other confounders of childhood malnutrition, morbidity and mortality. To obtain adjusted risk of small size at birth on childhood malnutrition, morbidity and mortality, we employed multivariate analysis techniques using multiple logistic regression models (for malnutrition and morbidity) and hazard model (for mortality), after controlling the additional effects of the potential confounders, namely maternal age, education, household wealth status, parity, sex of child, antenatal care use, region of residence and place of residence. The adjusted risk was measured by the odds ratio (OR). Table 6 presents the ORs with 95% confidence intervals (CIs) estimating the risk of small size at birth having childhood malnutrition, morbidity and mortality, compared with the reference group (i.e. average size at birth) for each

Table 5. Neonatal, post-neonatal, infant and under-five mortality rate by size at birth, Bangladesh 2014

Mortality indicators	Birth size		All	P-value	Number of death (n=4897)
	Small	≥ Average			
Neonatal mortality rate	54.02	21.43	28.18	0.001	138
Post-neonatal mortality rate	12.16	9.05	10.00	0.005	49
Infant mortality rate	66.18	30.48	37.98	0.001	187
Under-five mortality rate	68.06	41.26	45.94	0.007	225

Table 6. Multiple logistic regression analysis of nutritional (stunting, wasting, underweight) and morbidity (fever, diarrhea, ARI) status and proportional hazard analysis of mortality (neonatal, post-neonatal and under age 5) showing the odds ratio (with 95% confidence interval) over children's small size at birth, BDHS 2014

Outcome variables	Odds ratio (OR)	95% CI of Odds ratio	P-value
Stunting (yes)	1.59	(1.26, 2.76)	0.000
Wasting (yes)	2.23	(1.67, 3.34)	0.000
Underweight (yes)	1.94	(1.63, 2.43)	0.000
Had fever (yes)	1.09	(0.76, 1.35)	0.105
Had Diarrhea (yes)	1.63	(1.14, 3.02)	0.032
ARI (yes)	1.16	(0.79, 1.71)	0.425
Neonatal death (yes)	2.43	(1.12, 3.84)	0.016
Post-neonatal death (yes)	1.47	(0.98, 2.27)	0.046
Infant death (yes)	1.84	(1.08, 3.23)	0.032
Under five death (yes)	1.78	(1.13, 3.42)	0.017

Note: Results under multivariate analysis are based on controlling the effect of potential confounders like maternal age, education, household wealth status, parity, sex of child, antenatal care use, region of residence and place of residence.

of the indicators of nutritional status, morbidity and mortality.

The results indicate that after controlling the confounding effects of socio-economic and demographic factors, there are significant higher risk of malnutrition and mortality among children born with small size than the children born with average size. Thus, size at birth of children is a strong predictor of childhood malnutrition and mortality. The risk of stunting was found to be 1.6 times higher among children born with small size than the children born with average size (OR=1.59, 95% CI: 1.26 - 2.76). Similarly, the risk of wasting was found to be 2.2 times higher among children born with small size than the children born with average size (OR=2.23, 95% CI: 1.67 - 3.34). The analysis shows that the risk of all types of childhood mortality were significantly higher among children born with small size compared to children born with average size. The highest effect of birth size on death was found during neonatal (age 0-1 month) period. Neonatal deaths' rate was found to be 2.4 times higher among children born with small size compared to children born with average size (OR=2.43, 95% CI: 1.12 - 3.84). Although children born with small size had higher risk of childhood morbidity from fever, diarrhea and ARI, but after controlling the effects of potential confounders, the risks of having diarrhea appeared as significant.

Discussion

This study utilized small size at birth as a proxy of the low birth weight (LBW) and examined its effect on childhood mortality, morbidity and malnutrition in Bangladesh. According to the 2014 BDHS data, one in every five (20%) live births was found to be small in size in Bangladesh. The corresponding figure was found to be 17.2% in 2011 (28), indicating that the rate of small size babies is on the rise in Bangladesh. The estimated proportion of small size babies observed in this study is consistent with recent estimate of the proportion of LBW in Bangladesh. Using data from the Multiple Indicator Cluster Survey (MICS) 2012–13 of Bangladesh, Khan et al. (29) reported that 20% of the live births had LBW in Bangladesh. Our estimate of the proportion of infants with small size at birth in Bangladesh is comparable with the reported estimates of the proportion of small size babies at birth in a neighboring country Nepal. The proportion of small size infants was found to be 16% in Nepal in 2011 (24). Small size babies are more likely to be girl and 1st or higher order births. They are more likely to occur to very young (< 20 years) or older (≥ 35 years) mothers, mothers with low socio-economic status and mothers with no antenatal care visits.

The findings of this study demonstrated a significant independent effect of small size at birth on childhood malnutrition, mortality and morbidity (i.e. diarrhea) in Bangladesh. Children born with small size are more likely to be malnourished (stunted, wasted and underweight) than the children born with average size. Our adjusted analysis indicates that children born with small size had 1.6 to 2.2 times higher risk of stunting, wasting or underweight than their peers with average size. A previous study in Bangladesh also reported that children's birth weight is an important determinant of their nutritional status (30). Our findings are consisted with the findings of similar studies based on effect of LBW on nutritional status of children (31-34). It is worth mentioning here that malnutrition among young children is related with many factors including maternal malnutrition, poor socio-economic condition and prenatal and postnatal care (35). Both the children born with small size and average size are potentially exposed to these factors. However, small size or LBW babies fall behind the race of catch up growth during their first few years of life than the babies born with average size or normal weight (32). In a previous study in the urban slum in Bangladesh, Arifeen et al. (32) observed that children with normal birth weights gain an average of 73 g more than LBW children during their first three months of life.

The present study identified diarrhea as the predominant morbidity among children born with small size compared to average size infants. After controlling the potential confounder, small size babies were found to have 1.6 times higher risk of diarrhea than the babies born with average size. In this study, small size at birth was not identified as a significant risk factor for fever or ARI. Our findings are consistent with the findings of a study in north east Brazil, reporting LBW infants had increased risk of diarrhea but not respiratory infection (31). In a study in Sri Lanka, strong evidence for an association between LBW and increased risk of diarrhea was found (36). On the other hand, a number of studies have also reported that LBW was not a risk factor for infant morbidity. For example, in the USA, no significant differences in frequency of diarrhea episodes between LBW and NBW infants was found (37,38). In another study in Guatemala, no consistent relation was found between LBW and infection, or cumulative clinical manifestations (39).

The analysis of this study identified small size at birth as a very strong predictor of mortality risk during the first five years of life. This finding support the claims of the previous studies that children born as small in size or LBW are more likely to die during childhood than the children born with average size or NBW, irrespective of developing and developed countries (3,5,31,40,41). Our analysis revealed that children with small size at birth had 1.8 times higher mortality rate during their first five years of age, compared to average size children. The highest effect of birth size was found in neonatal period. The risk of death of small size babies in neonatal period was found to be 2.4 times higher compared to average size babies.

With recent advances in modern obstetric and neonatal care and technological development across the globe including Bangladesh, doctors today are able to keep smaller premature babies alive (42). Because of this, more and more small or LBW babies are being reported as live births. However, these new survivors remain at a high risk for health and developmental problems. As a result, an increasing number of these babies do not survive during their first birthday and childhood period, and thus resulting a higher mortality among small size or LBW babies.

The finding of this study that out of 1000 live births with small size at birth, 54 die within first month of their life in Bangladesh is perhaps one of the highest neonatal mortality rates. At the same time the overall neonatal mortality rate in Bangladesh was 28 deaths per 1000 live births. It is worth mentioning here that Bangladesh has made significant progress in reduction of overall childhood mortality over the last two decades. A 65 percent decline in under-5 mortality from 133 to 46 deaths per 1,000 live births over the period 1993 to 2014 has occurred in Bangladesh (18). Most of these declines in overall childhood mortality occurred during post neonatal period, and thus mortality has become increasingly concentrated in the earliest months of life. The time series data from the BDHSs over the last two decades indicate that the proportion of neonatal deaths relative to overall under-5 mortality has increased from 39% in 1993 to 47% in 2003 and further increased to 61% in 2014 (18, p102). The persistent increase in the proportion of neonatal deaths might be linked with the high rate of small size or LBW in Bangladesh to some extent.

Our finding of very high neonatal mortality among the children with small size in Bangladesh deserves special attention by the national child health care program. The causes of high neonatal mortality among infant in general, and among small size infants in particular, need to be identified to help direct appropriate interventions for reduction of neonatal mortality in Bangladesh. Recent studies conducted in rural Bangladesh identified birth asphyxia, prematurity/low birth weight, sepsis, respiratory distress syndrome and pneumonia as the major causes of neonatal mortality (43-45). Birth asphyxia alone accounted for 45% of neonatal deaths in rural Bangladesh (45), compared to the global average of 23-29% (46, 47). The higher rate of neonatal deaths due to birth asphyxia in Bangladesh might be related to inadequate prenatal and postnatal care as well as the lack of appropriate resuscitation care for newborns at birth. According to the findings of the 2014 BDHS, among the women who gave birth in the three years preceding the survey, 21.4% mothers never received any ANC, only 31.3% received WHO recommended at least four ANC visits, and 36% mothers received no post-natal care (PNC) visits (48). In addition, more than sixty percent (63%) births were delivered at home under the supervision of traditional birth attendants or relatives or friends, and thus less likely to receive resuscitation care at birth. There is a need for targeted interventions aimed at decreasing the high rate of small size at birth or LBW in Bangladesh and increase the frequency of timely ANC visits, PNC visits and delivery at health facility which in turn would reduce the neonatal and infant mortality rates.

This study has many strengths as well as limitations. Among the strengths, firstly, it is based on national level survey data that used sound methodology and validated questionnaires. The survey covered a large number of socioeconomic, demographic and health related variables. Secondly, the findings of the study are generalizable for the whole country as the statistical analysis are based on nationally representative survey data collected through the multi stage cluster sampling design. Thirdly, this study is among the few studies in developing countries and the first study in Bangladesh which, in the absence of birth weight data, used readily available birth size as a proxy of birth weight. Nevertheless, the study is not free from limitations. The data used in the study is cross sectional in nature and there is possibility that some responses may suffer from recall biases including the variable on maternal perceived size at birth of their babies. Another limitation of the study includes the inability to control for several important variables, such as maternal weight gains during pregnancy, pre- and during pregnancy, health status, food consumption, diet and life style of pregnant mothers, as the survey did not collect information on these variables.

Conclusion

The findings of this study indicate that babies born with small size are more vulnerable in terms of childhood nutrition, morbidity and mortality. Our findings of higher incidence of childhood malnutrition, morbidity and mortality among small size babies compared to average size babies underscores the need for a more focused newborn care strategy for the small size babies, so that appropriate management of those vulnerable group of babies can be made universally available at all level of health care services. Since births at home tend to be the norm in Bangladesh, the skilled community health workers and trained traditional birth attendants could be promoted to provide home-based care for both birth asphyxia and for babies born with small size. These types of interventions have been proved effective in reducing the number of deaths due to asphyxia in settings with high rate of home births elsewhere (49, 50). Health education to parents, regular follow up of small size babies through trained health workers and training of grass root level health workers on care of small size babies could be some potential interventions for improving the health of small size babies.

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Conflict of interests

The authors have no conflict of interest to declare.

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