Household Food Security and Birth Size of Infants: Analysis of the Bangladesh Demographic and Health Survey 2011

Morseda Chowdhury,[1,2] Michael J Dibley,[2] Ashraful Alam,[2] Tanvir M Huda,[2] and Camille Raynes-Greenow[2]

[1]Health Nutrition and Population Programme, BRAC, Bangladesh and [2]School of Public Health, The University of Sydney, Camperdown NSW 2006, Australia

Abstract

Background: More than one-third of the population in Bangladesh is affected by household food insecurity in a setting where child survival and well-being are under threat. The relation between household food security and birth size of infants is an important area to explore given its explicit effect on mortality and morbidity.

Objective: Our study aims to estimate the association between household food security and birth size of infants.

Methods: For the analysis we used a nationally representative cross-sectional survey of 8753 households with a live birth between 2006 and 2011, collected under the Bangladesh Demographic and Health Survey (BDHS) 2011. We investigated the association of small birth size with the following potential explanatory variables: sex of the child; birth interval; mother's age at birth, height, body mass index (BMI), anemia status, parity, previous pregnancy loss, antenatal care visits, exposure to television, and participation in health care decisions; cooking fuel; parents' education level; region; place of residence; and wealth index using Pearson's chi-square test. We then constructed a multivariable logistic regression model of birth size on food security after controlling for all potential confounders as well as the cluster sampling design. The odds ratio (OR) was reported for each of the covariates; a P value <0.05 was interpreted as statistically significant.

Results: A total of 1485 (17.3%) children were reported as small at the time of birth and more than one-third of households (35.7%) experienced some degree of food insecurity. Mothers from food-insecure households had 38% higher odds of having small-size infants compared to food-secure households (adjusted OR: 1.38; 95% CI: 1.19, 1.59; $P < 0.001$).

Conclusion: Household food security is one of the key factors associated with small birth size. Interventions to increase birth size should target women belonging to food-insecure households. *Curr Dev Nutr* 2018;2:nzy003.

Introduction

Birth size significantly impacts newborn survival and subsequent health and well-being. Low birth weight (LBW) (<2500 g) indirectly contributes to 60% of newborn mortality (1). Those who survive are at increased risk of developmental delays, cognitive and behavioral problems, subnormal growth, and diseases in later life (2–5). Therefore, preventing LBW may be an important consideration for countries in development transition.

Factors contributing to LBW are multidimensional and complex in nature and vary by geography (6). Findings from studies have suggested that several sociodemographic, reproductive, and nutritional factors contribute to LBW; however, the impact of household food security on LBW has yet to be examined (7–10). Household food security is a factor that is closely linked with household nutrition, which could impact on birth weight. There is scant evidence of a relation

Keywords: birth size, food security, perinatal nutrition, BDHS, Bangladesh

Manuscript received July 26, 2017. Initial review completed November 6, 2017. Revision accepted December 31, 2017. Published online February 12, 2018.

Morseda Chowdhury has been awarded with a postgraduate research (PhD) scholarship from The Australian Government (Endeavour scholarship).

Author disclosures: MC, MJD, AA, TMH, and CR-G, no conflicts of interest.

Address correspondence to MC (e-mail: morsheda.c@brac.net).

Abbreviations used: ANC, antenatal care; BDHS, Bangladesh Demographic and Health Survey; EA, enumeration unit; LBW, low birth weight.

between household food insecurity and LBW, especially in low-income countries. Only one study conducted in the United States has shown that food-insecure women are 3 times more likely to give birth to LBW infants [OR: 3.2 (95% CI: 1.4, 7.2)] (11). However, the definition of food insecurity differs between developed and developing country contexts. In the United States, the NHANES III (1988–1994) reported that, among adults, food insecurity resulted in consumption of a less-healthy diet and deficiency in nutrients (12). In developed countries the prime concern is quality of food rather than quantity or accessibility, whereas for developing countries both quality and accessibility are issues. Despite the lack of evidence and understanding of the quantitative effects of food insecurity on birth weight in resource-poor settings, there is evidence that food insecurity worsens diet quality among women of childbearing age, reduces micronutrient intake, and reduces energy consumption by 50% (13). There is strong evidence that poor maternal nutrition during pregnancy leads to intrauterine growth restriction, and thus LBW (6, 14–17). More precisely, maternal nutrition affects the weight of the fetus during the last half or last trimester of pregnancy (17).

In Bangladesh, ∼41% of households live in a food-insecure environment; although food insecurity is more prevalent among the poor, it extends to the higher-economic quintiles (18). Dietary diversity is reduced during pregnancy and the early postpartum period among food-insecure households. This is largely due to reductions in all types of animal-source foods, especially dairy products, eggs, meat, and fish (2). The average daily protein requirement in pregnancy is 71 g. Low maternal protein intake in the second and third trimesters is associated with decreased birth weight (3). In 2010, Bangladesh was ranked fourth in the global burden of LBW (19), and over half of Bangladeshi infants were born with LBW (20). Therefore, our aim is to investigate the association between household food security and infant's size at birth, which has not previously been examined in a low- and middle-income country. These findings are important for policy makers who are developing strategies to reduce LBW, and consider household food insecurity as one of the important determinants.

Methods

This study used data from the Bangladesh Demographic and Health Survey (BDHS) 2011, which was based on a 2-stage stratified sample of households. In stage 1, 600 enumeration units (EAs) were selected with a probability proportional to the EA size, giving 207 clusters in urban and 393 in rural areas. In stage 2, a systematic sample of 30 households on average was selected per cluster, from urban and rural areas separately, and for each of the 7 regions of Bangladesh. Reproductive histories were collected from all married women aged 12–49 y. The survey asked female respondents about all their births. In order to reduce recall bias, detailed information regarding childbirth was asked only for the children aged <60 mo (21). We used birth data for women who had singleton live births in the last 5 y preceding the survey for our analysis.

Variables

We examined infant birth size as the categoric outcome variable, 1 = small; 0 = not small. In the BDHS, direct measurement of birth weight is not available, because birth weight is unknown for many babies, particularly for those born at home. However, the survey collected information on mothers' perception of the size of the infants at birth, which was used as a proxy for birth weight; this is commonly done in developing countries (22). For brevity from here on we will refer to this as infant birth size. In the BDHS mothers ranked their children on a scale of "very small," "smaller than average," "average," "larger than average," and "very large" at birth. We considered "very small" and "smaller than average" as "small," and "average," "larger than average," and "very large" as "not small."

The main exposure variable was the household food security score. The World Food Summit in 1996 defined food security as "when all people, at all times, have physical and economic access to sufficient safe and nutritious food to meet their dietary needs and food preferences for a healthy and active life" (23). The BDHS used a broader definition specifying the availability of food and a person's access to it. The BDHS asked the following 5 questions to all ever-married women aged 15–49 y about the last 12 mo: *1*) how often they ate 3 square meals (full stomach meals) a day: *2*) how often they skipped entire meals; *3*) how often they personally ate less food; *4*) how often they or any family members had to eat grains other than rice (which is a staple food); and *5*) how often their family had to ask for food from relatives or neighbors. Each question was assigned a score ranging from 0 to 3, with 0 corresponding to "never," 1 to "rarely," 2 to "sometimes," and 3 to "mostly/often." The question about "square meals" was coded in reverse to be consistent with other items, in which higher frequency indicates more severe food insecurity. All the food-frequency responses were summed into a single score for each ever-married woman. The composite score ranged from a minimum of 0 to a maximum of 15, which was then classified into 4 categories: 0 = "food secure," 1–5 = "mild food insecurity," 6–10 = "moderate food insecurity," and 11–15 = "severe food insecurity" (21). We examined the internal consistency ("reliability") of the food security Likert questions that formed the food insecurity scale by calculating Cronbach's α.

We considered the relevant child, mother, and household level covariates as explanatory variables in our analysis. The child covariates included sex of the child, birth interval, and year and month of birth. The maternal covariates included mother's age at birth, height, BMI, anemia status, parity, any previous pregnancy loss, number of antenatal care (ANC) visits, education, participation in health care decision making, and exposure to television. The household level covariates included father's education, place of residence, region, access to clean cooking fuel, and wealth index.

We grouped together continuous variables using clinical and epidemiologic cut-offs and treated these as categoric variables by creating dummy variables with the lowest group serving as the reference group to check the validity of linearity assumption. For example, ANC visit and parity as category better fitted the model, thus we converted these into categoric variables. Based on WHO recommendation on the basic ANC model, the number of ANC visits was categorized into 3 groups: no visit, 1–3 visits, and ≥4 visits (24). We divided mother's parity into 3 categories: first birth, parity 1–4, and parity ≥5. For both parents' education the reference group we chose was the highest group (higher education group). The BDHS defines birth interval as the length of time between 2 successive live births, whereas the WHO recommendation is based on birth-to-pregnancy intervals (25). We calculated mother's age at birth by deducting the child's age from the mother's age (self-reported). Height, BMI, and anemia status were the measures taken at the time of the interview. Any previous pregnancy with either stillbirth or abortion or miscarriage was termed as previous pregnancy loss. Considering the health risks, type of cooking fuel was categorized into clean fuel (electricity, liquid petroleum gas, natural gas, and biogas) and polluting fuel (coal, lignite, kerosene, charcoal, wood, straw or shrubs or grass, agricultural crop, animal dung, and others). In the BDHS, wealth is used as a measure of economic status, which is constructed using coefficients and assets, services, and amenities that are specific to urban and rural areas, thought to be correlated with a household's economic status (26). Wealth index was generated with a statistical procedure known as principal components analysis, which puts the individual households on a continuous scale of relative wealth known as the wealth index score. From this, the national-level wealth quintiles are obtained by assigning the wealth index score for each household member, ranking each person by his or her score, and then dividing the ranking into 5 equal categories, each comprising 20% of the population (21). We have created a year-month variable combining year of birth (e.g., 2010) with month of birth (e.g., 02), so a child born in Feruary 2010 would have a year-month variable value of 201002.

Statistical analysis

The BDHS 2011 used individual sampling weights to account for different sampling probabilities and different response rates. Since the sample is a 2-stage stratified cluster sample (household and cluster), sampling weights were calculated separately for each sampling stage and cluster based on sampling probabilities (21). For univariable and multivariable analysis we applied STATA's survey estimation procedures (svy command) in order to account for the 2-stage cluster sampling design. We constructed a table reporting unweighted frequencies of participants with weighted percentages and weighted proportion of outcomes for each level of the variables, i.e., child, mother, and household (**Table 1**).

We examined the data to see if a mother had >1 singleton birth in the data set, to adjust for common maternal and environmental factors influencing pregnancy outcomes; however, we found no such births in our data.

We constructed survey-weighted logistic regression models to specify the dichotomous dependent variable [small (yes = 1; no = 0)] as the function of a set of explanatory variables. The survey-weighted logit model reported estimates of model parameters after correcting the variance estimates, using information from the survey design. Univariable survey-weighted logistic regression reported crude ORs along with the 95% CI. Considering the large sample size and epidemiologic evidence, all variables, irrespective of statistical significance, were entered into the base model (multivariable survey-weighted logistic regression model) except mother's anemia status and birth interval. Mother's anemia status was assessed on a subsample of the population ($n = 2674$), and birth interval had 3095 missing values (mothers who had only one birth). Variables entered into the baseline model were checked for collinearity, which potentially can produce unstable estimates or nonconvergence. We investigated for any strong associations among the variables by finding the correlation between continuous variables and by cross-tabulating categoric variables. Parity and mother's age was found to be moderately correlated ($r = 0.7$) and the latter was excluded from the baseline model. All the continuous variables were checked for linearity assumption, in contrast to the models in which the specific variables were treated as categoric variables. The final decision was made based on the Akaike information criterion (AIC) and the Bayesian information criterion (BIC); the models with the lowest values of these 2 criteria were assumed to provide a better-fitting model. Nonsignificant variables (that were neither confounders nor otherwise needed in the model) were removed one at a time using a backward elimination process, starting with the least-significant overall P value to get the final model. We ruled out the possibility of any interaction between the main exposure (food security) and other variables by including interaction terms for birth month and region in the model; and with a backward elimination process, sequentially eliminated all insignificant interaction terms ($P > 0.001$), starting with the least-significant one. In the multivariable model, the adjusted OR with 95% CI was reported for all variables. Statistical significance was considered at $P < 0.05$ levels.

We have investigated the sensitivity of retrospective recall of household food security status by restricting the analysis to births occurring within 1 y of interview, the recall period for the food security questionnaire. We adjusted for season of birth by entering a year-month of birth variable and checked whether the effect of food security on small birth size is stronger. We classified the year-month of birth variable as lean-season (October–December) and nonlean-season births (January–September) to test the effect of seasonal food shortages on food security and birth size. Mothers who had been exposed to lean season in their third trimester were examined separately. As the lean season is predominantly a feature of some of the districts of the northwestern part of Bangladesh, we restricted our analysis to Rangpur (a region in the northwest) in a lean season in a separate model. The STATA 13 software package was used for all statistical analyses.

Results

There were 8753 children aged <5 y born between 2006 and 2011 who had birth size data in the BDHS 2011; of these, 8588 were singleton births. A total of 1485 (17.3%; 95% CI: 16.2%, 18.5%) children were reported as being born small by their mothers. The male:female sex ratio among the children was 51:49. The majority of the births (83%) had a birth interval of ≥2 y. The mean ± SD age of mothers at the time of pregnancy was 23 ± 6 y; almost a third of the mothers (32%) were in their teens and were having their first birth (28%). The mean ± SD height of mothers was 151 ± 6 cm; 13% of the mothers were short statured (<145 cm); more than a quarter of mothers (27%) were thin [BMI (kg/m^2) <18.5]; and close to half (45.3%) of the mothers had some degree of anemia at the time of the survey. Eighteen percent of the mothers had a history of pregnancy loss. Around two-thirds of the mothers reported having had an ANC visit in the recent pregnancy, but of them only 41% had ≥4 visits. The majority of the mothers were literate (80%); this rate was slightly higher than that of the fathers (70%). Sixty percent of mothers reported participating in maternal health care decisions either alone or with their husbands, and 58% were exposed to television. Almost 80% of mothers were living in rural areas, 44% belonged to the poorest families, and only 11.8% of the families cooked with clean fuel (Table 1).

More than a third of households in our sample (35.7%) experienced some degree of food insecurity in the 12 mo preceding the survey. A

TABLE 1 Characteristics of the mothers giving birth between 2006 and 2011 from the Bangladesh Demographic and Health Survey 2011 (n = 8588)[1]

Factors	*n* (weighted)	Relative frequency, %	Mean ± SD	Small birth size,[2] %
Food security			N/A	
Food secure	5537	64.3		15.7
Food insecure	3069	35.7		20.3
Sex of child			N/A	
Male	4416	51.2		15.3
Female	4214	48.8		19.5
Birth interval, mo			53.6 ± 30.2	
<33	1504	17.4		16.8
≥33	7126	82.6		17.5
Mother's age at birth, y			23.0 ± 5.7	
<20	2770	32.1		18.9
20–34	5482	63.5		16.5
>34	378	4.4		18.6
Mother's height, cm			150.9 ± 5.5	
<145	13	13.0		18.7
≥145 to <150	29	29.5		18.0
≥150 to <155	33	33.1		17.4
≥155	24	24.5		15.7
Mother's BMI,[3] kg/m^2			20.8 ± 3.5	
Thin	2332	27.0		19.8
Normal	5137	59.5		16.8
Overweight	1161	13.5		14.7
Mother's anemia status[4]			N/A	
No anemia	1463	54.7		18.4
Mild anemia	1030	38.5		17.6
Moderate to severe anemia	182	6.8		20.0
Parity, *n*			2.5 ± 1.6	
First birth	2454	28.4		18.0
Subsequent births	6176	71.6		17.1
Any pregnancy loss			N/A	
No	7078	82.0		16.9
Yes	1552	18.0		19.6
ANC visits, *n*			2.4 ± 2.7	
No visit	2579	35.5		20.2
<4 visits	2959	40.7		17.2
≥4 visits	1735	23.9		13.1
Mother's education			N/A	
No education	1753	20.3		19.2
Primary	2659	30.8		17.4
Secondary	3622	42.0		17.4
Higher	596	6.9		11.4
Mother's participation in health care decision			N/A	
No	3396	40.0		19.2
Yes	5095	60.0		16.2
Mother's exposure to television			N/A	
Not at all	3597	41.7		17.7
≤1 time/wk	5032	58.3		17.1
Father's education			N/A	
No education	2577	29.9		18.9
Primary	2523	29.3		17.9
Secondary	2460	28.5		16.9
Higher	1064	12.3		13.5
Region			N/A	
Barisal	482	5.6		13.7
Chittagong	1977	22.9		20.7
Dhaka	2685	31.1		16.4
Khulna	780.2	9.0		16.0
Rajshahi	1125	13.0		16.3
Rangpur	912.6	10.6		13.7
Sylhet	669.5	7.8		22.1

(*Continued*)

TABLE 1 (*Continued*)

Factors	*n* (weighted)	Relative frequency, %	Mean ± SD	Small birth size,[2] %
Place of residence			N/A	
Urban	1915	22.2		15.0
Rural	6715	77.8		18.0
Cooking fuel			N/A	
Clean fuel	912	11.8		13.5
Polluting fuel	6819	88.2		18.2
Household wealth index			N/A	
Poorest	1727	20.0		19.4
Poorer	1727	20.0		18.9
Middle	1726	20.0		17.1
Richer	1727	20.0		17.0
Richest	1725	20.0		14.4

[1]Missing values for anemia, birth month, birth interval, ANC, cooking fuel, BMI, height, participation in healthcare decision, nutrition score, husband's education, and exposure to TV were 5914, 3842, 3095, 1343, 886, 190, 186, 146, 21, 6, and 2, respectively. ANC, antenatal care; N/A, not applicable.
[2]Small birth size is defined as birth size "small" and "not small."
[3]Thin, normal, and overweight are defined as BMI (in kg/m^2) <18.5, 18.5–24.9 and ≥25.0, respectively.
[4]Mild anemia is defined as hemoglobin concentrations 10.0–11.9 g/dL (nonpregnant) and 10.0–10.9 g/dL (pregnant), and moderate to severe anemia is defined as hemoglobin concentrations ≤9.0 g/dL (pregnant and nonpregnant).

high proportion of households experienced ≥1 of the specific conditions that were used to assess food insecurity; nearly 1 in 5 mothers did not eat 3 square meals/d (18.8%) or had skipped an entire meal (18.6%) in the previous 12 mo. More than one-fifth (22%) of the mothers ate less because there was not enough food available for them to eat during the 12 mo before the survey (**Table 2**). The Cronbach's α of 0.91 indicates a high level of internal consistency for the Likert scale used in the BDHS. The 5 questions in this questionnaire all reliably measure the same latent variable "feeling of food insecurity."

Table 3 shows that mothers from food-insecure households were 37% more likely to give birth to small infants compared to food-secure mothers (OR: 1.37; 95% CI: 1.20, 1.57; $P < 0.001$). Once adjusted for clustering and other variables in the model, the effect remained unchanged (OR: 1.37; 95% CI: 1.18, 1.59; $P < 0.001$). Compared to males, female infants had 41% higher odds of being smaller at birth (OR: 1.41; 95% CI: 1.24, 1.62; $P < 0.001$) after adjusting for other factors. Mother's parity was found to mitigate small birth size: compared to first birth there were lower odds of delivering small infants in subsequent births (OR: 0.81; 95% CI: 0.70, 0.94; $P = 0.006$). The results showed that the small size at birth was decreased by 6% (OR: 0.94; 95% CI: 0.91, 0.97; $P < 0.001$) for every additional ANC visit. We observed a significant association between birth size and geographical region. Mothers from Chittagong and Sylhet regions had higher odds of having small infants compared to those from Barisal (OR: 1.62; 95% CI: 1.21, 2.18; $P = 001$ and OR: 1.71; 95% CI: 1.31, 2.24; $P < 0.001$ for Chittagong and Sylhet, respectively). In the subgroup analysis, ANC visit appeared low among mothers of Sylhet and Chittagong (not shown in the table).

The relation between food security and birth size was similar in the interview year and the preceding years, indicating that the food security status of households remained mostly unchanged over the previous 5-y period. We observed only a small increase in the effect of food security on birth size (7%) when the model was adjusted for year-month of birth variable. Similarly, we did not find any change in effect of food security on birth size when adjusted for lean season (mothers exposed to lean season in their third trimester). We also could not establish any effect of lean season on birth size even in the most vulnerable region affected by seasonal food production variation (Rangpur). Some of the other regions were found to be at risk of having more small-size infants (Chittagong and Sylhet). The odds of small birth size were significantly higher in both food-insecure poor households (OR: 1.39; 95% CI: 1.11, 1.76; $P = 0.005$) and food-insecure nonpoor households (OR: 1.32; 95% CI: 1.08, 1.62; $P = 0.007$) compared to the respective food-secure groups. We observed a gradient in the rate of small birth size along the wealth quintiles; however, there was no evidence of an association between wealth and birth size after controlling for food security.

Discussion

The prevalence of small birth size in the study sample was 17.3%, which varied by household food security status. The odds of having smaller infants were higher for food-insecure households, female children, lower birth orders, mothers who had fewer ANC visits, and those who were living in Chittagong or Sylhet regions. The other plausible determinants

TABLE 2 Household experience of specific food insecurity–related conditions

	Never, *n* (%)	Rarely (1–6 times this year), *n* (%)	Sometimes (7–12 times this year), *n* (%)	Mostly/often (few times each month), *n* (%)
Had 3 square meals	44 (0.7)	219 (3.5)	219 (14.0)	5052 (81.8)
Skipped entire meals	5047 (81.9)	793 (12.6)	242 (3.8)	105 (1.6)
Ate less food	4827 (78.4)	878 (13.8)	346 (5.7)	136 (2.1)
Ate wheat or rice substitute	5136 (83.6)	735 (11.6)	239 (3.8)	77 (1.1)
Asked for food from relatives or neighbors	4171 (66.6)	1338 (22.0)	491 (8.6)	187 (2.8)

TABLE 3 Effects of household food security on birth size of infants[1]

Factors	Crude OR (95% CI)	*P* value	Adjusted OR (95% CI)[2]	*P* value
Food security				
Food secure	Reference			
Food insecure	1.37 (1.20, 1.57)	<0.001**	1.38 (1.19, 1.59)	<0.001**
Sex of child				
Male	Reference			
Female	1.35 (1.19, 1.53)	<0.001**	1.41 (1.24, 1.62)	<0.001**
Birth interval	1.01 (0.98, 1.05)	0.47	—	
Mother's age at birth	1.00 (0.98, 1.01)	0.57	—	
Mother's height	0.99 (0.97, 1.00)	0.013*	—	
Mother's BMI	0.97 (0.95, 0.98)	<0.001**	—	
Mother's anemia status				
No anemia	Reference			
Mild anemia	0.95 (0.74, 1.23)	0.72	—	
Moderate to severe anemia	1.11 (0.71, 1.74)	0.64	—	
Parity				
First birth	Reference			
Subsequent births	0.94 (0.81, 1.08)	0.35	0.81 (0.70, 0.94)	0.006*
Previous pregnancy loss				
No	Reference			
Yes	1.20 (1.01, 1.43)	0.035*	—	
ANC visit	0.93 (0.90, 0.96)	<0.001**	0.94 (0.91, 0.97)	<0.001**
Mother's education				
No education	1.85 (1.37, 2.50)	<0.001**	—	
Primary	1.64 (1.21, 2.23)	0.002*	—	
Secondary	1.64 (1.22, 2.21)	0.001*	—	
Higher	Reference			
Mother's participation in health care decision				
No	Reference			
Yes	0.81 (0.71, 0.93)	0.003*	—	
Mother's exposure to television				
Not at all	Reference			
≤1 time/wk	0.96 (0.83, 1.10)	0.55	—	
Father's education				
No education	1.49 (1.18, 1.90)	0.001*	—	
Primary	1.40 (1.12, 1.75)	0.003*	—	
Secondary	1.31 (1.03, 1.67)	0.031*	—	
Higher	Reference			
Region				
Barisal	Reference			
Chittagong	1.64 (1.23, 2.20)	<0.001**	1.62 (1.21, 2.18)	0.001*
Dhaka	1.23 (0.93,1.63)	0.14	1.20 (0.90, 1.60)	0.21
Khulna	1.20 (0.90, 1.61)	0.22	1.10 (0.81, 1.49)	0.54
Rajshahi	1.22 (0.90, 1.65)	0.19	1.13 (0.83, 1.54)	0.45
Rangpur	1.00 (0.74, 1.35)	0.98	1.00 (0.73, 1.37)	1.00
Sylhet	1.78 (1.36, 2.32)	<0.001**	1.71 (1.31, 2.24)	<0.001**
Place of residence				
Urban	Reference			
Rural	1.25 (1.05, 1.48)	0.01*	—	
Cooking fuel				
Clean fuel	Reference			
Polluting fuel	1.43 (1.11, 1.84)	0.005*	—	
Household wealth index				
Poorest	1.43 (1.15, 1.78)	0.001*	—	
Poorer	1.39 (1.11, 1.73)	0.004*	—	
Middle	1.23 (0.99, 1.53)	0.06	—	
Richer	1.22 (0.97, 1.52)	0.09	—	
Richest	Reference			

[1] *Significant at $P < 0.05$; **Significant at $P < 0.001$. ANC, antenatal care.
[2] The multivariable model was adjusted for sex of child, parity, ANC visit, and region.

not found significant in this paper were mother's age at birth, height, BMI, anemia status, birth interval, previous pregnancy loss, exposure to television, and participation in health care decisions, and the cooking fuel used in the household; and both parents' education; place of residence; and household wealth status.

We found that the children belonging to food-insecure households were more likely to be small at birth than those belonging to food-secure households. It is well established that household food security is strongly associated with child nutrition. A study conducted among 6858 urban poor children in Kenya found that the risk of stunting increased by 12% among children from food-insecure households (27). Infants in food-insecure households in Bangladesh were found to receive poor-quality feeding between the ages of 6 and 12 mo ($n = 1343$) compared to infants in food-secure households (28). Women are more vulnerable to food insecurity; they may reduce their intake of certain foods to cope with household food insufficiency and to protect other family members, especially children (13). Food insecurity in terms of food shortage imposes additional stress on pregnant women (29). Pregnant women from food-insecure households had almost 3 times higher odds of having prenatal depressive symptoms compared to food-secure women (30). Reduced nutrient intake during pregnancy due to food shortage in conjunction with depression results in poor placental development and reduced nutrient transfer from the mother to the fetus (27, 31). And any such nutritional insult in pregnancy results in suboptimal fetal growth, leading to small birth size (or LBW) (6, 7).

Food insecurity can be chronic or transitory for some households. The transitory food-insecure do not consume adequate food during the lean season as a result of production losses or price hikes (32). Monga, a period of seasonal food insecurity in Bangladesh, is defined by lack of access to food due to loss of income preceding a major harvest between mid-September and mid-November (33). In our analysis we did not find any association between monga and food security or birth size, even in the most monga-prone regions, which might be the result of interventions to dampen seasonal price hikes and increase nonfarm income in those regions. Over the past 2 decades seasonal price hikes have been halved by the expansion of the harvesting season and the introduction of high-yielding varieties of rice (34).

In 2007–2008, Bangladesh experienced soaring prices of staple cereals, which threw millions into the urgent-hunger category (35). However, our data failed to demonstrate any evidence of an association between food security status of households or risk of small birth size at specific birth years.

Our findings suggested a significant regional variation in Bangladesh, with 2 regions, Sylhet in the north and Chittagong in the south, showing an increased risk of small birth size. This finding is not surprising for Sylhet, which has historically low ANC coverage, low child nutrition, and high neonatal mortality (36). On the other hand, Chittagong is doing well in 2 out of 3 of these measures. This difference cannot be explained by the economic situation either. The incidence of poverty is lower in those regions compared to the national level (31.5% national compared to 26.2% in Chittagong and 28.1% in Sylhet) (37). The probable explanation could be the challenges people face in accessing health care services due to the difficult topography (hilly areas and wetlands).

In this study, it is apparent that food security status was more efficient in predicting small birth size than was wealth status. We did not find any association between wealth status and birth size when controlling for food security, although wealth status was a strong predictor of food security and birth size.

The strength of our study is that it is based on a nationally representative sample survey that used a standardized methodology, and is able to examine geographic or regional variations in birth size. This is the first study, to our knowledge, to investigate the impact of household food security on birth size of infants in Bangladesh. The main limitation of the DHS data is that it is retrospective, covering the 5 y preceding the survey for almost all indicators except food security. For food security indicators, the recall period was 1 y prior to the interview; however, we included children born in the last 5 y. Therefore, we restricted our analysis to the births in the last year (coinciding with the food security recall period) and found no difference in coefficients from earlier years, indicating that the food security of most of the families seems not to have changed over the 5-y period. However, the sensitivity analysis (although useful and reassuring) does not completely fix the misaligned temporality, because restricting the analysis to births within 1 y of interview means that some of these births occurred before the full food security exposure period was completed. The second limitation is that the data could not establish significant seasonal variation in food insecurity, especially major trends, e.g., the food shortages of 2007–2008 and seasonal food shortages. As it was a nationwide survey, this study could not capture the seasonal effects of food insecurity on birth size, which are localized in several districts in northwestern Bangladesh and areas adjacent to rivers subject to flooding (38, 39). The third limitation is that due to unavailability of data, we could not examine the already well-known relation between gestational age and birth size in our analysis. The fourth limitation is the lack of precise birth weight data. In Bangladesh, birth weight is often not measured due to the large number of home births. We used mothers' perceived size of infants at birth as a proxy for birth weight. Some studies have reported that perceived birth size was associated with birth weight (9, 40).

From these findings, we conclude that infants born to food-insecure households were more at risk of being smaller at birth, which was aggravated by less utilization of ANC. The first-time pregnant mothers and those from Sylhet and Chittagong were more vulnerable to giving birth to smaller infants. Infant size at birth is an important predictor of early-life survival and future growth, development, and productivity. The findings from the present study, therefore, emphasizing the need for a comprehensive intervention strategy to alleviate household food insecurity and increase health care utilization. Further investigation is necessary to identify the factors responsible for small birth size among primiparous mothers and mothers living in Sylhet and Chittagong, and to address them accordingly. Maternal and infant nutrition condition in Bangladesh is in a critical state and needs immediate intervention to protect mothers and their unborn children from the dire consequences of undernutrition.

Acknowledgments

The authors' responsibilities were as follows—MC: designed and conducted the research, analyzed data, wrote the paper, and had primary responsibility for final content; MJD: provided critical guidance on statistical analysis; CR-G, AA, and TMH: critically reviewed the manuscript; and all authors: read and approved the final manuscript.

References

1. Black RE, Allen LH, Bhutta ZA, Caulfield LE, de Onis M, Ezzati M, Mathers C, Rivera J. Maternal and child undernutrition: global and regional exposures and health consequences. Lancet 2008;371:243–60.
2. Gupta ND, Deding M, Lausten M. The effect of low birth weight on height, weight and behavioral outcomes in the medium-run. Econ Hum Biol 2013;11(1):42–55.
3. Hack M, Klein NK, Taylor HG. Long-term developmental outcomes of low birth weight infants. Future Child 1995;5:176–96.
4. Fletcher JM. The medium term schooling and health effects of low birth weight: evidence from siblings. Econ Educ Rev 2011;30:517–27.
5. Goddeeris JH, Saigal S, Boyle MH, Paneth N, Streiner DL, Stoskopf B. Economic outcomes in young adulthood for extremely low birth weight survivors. Pediatrics 2010;126:e1102–e8.
6. Kramer MS. Determinants of low birth weight: methodological assessment and meta-analysis. Bull World Health Organ 1987;65:663–737.
7. Kabir A, Merrill RD, Shamim AA, Klemn RDW, Labrique AB, Christian P, West Jr KP, Mohammed N. Canonical correlation analysis of infant's size at birth and maternal factors: a study in rural northwest Bangladesh. PloS One 2014;9:e94243.
8. Hosain GMM, Chatterjee N, Begum A, Saha SC. Factors associated with low birthweight in rural Bangladesh. J Trop Pediatr. 2005;52(2):87–91.
9. Khanal V, Sauer K, Karkee R, Zhao Y. Factors associated with small size at birth in Nepal: further analysis of Nepal Demographic and Health Survey 2011. BMC Pregnancy Childbirth 2014;14(32).
10. Sebayang SK, Dibley MJ, Kelly PJ, Shankar AV, Shankar AH, the SUMMIT study group. Determinants of low birthweight, small-for-gestational-age and preterm birth in Lombok, Indonesia: analyses of the birthweight cohort of the SUMMIT trial. Trop Med Int Health 2012;17:938–50.
11. Bryant BAE, Grobman WA, Amsden LB, Holl JL. Chronic stress and low birth weight neonates in a low-income population of women. J Am Coll Obstetr Gynecol 2007;109:331–8.
12. Bhattacharya J, Currie J, Haider S. Poverty, food insecurity, and nutritional outcomes in children and adults. J Health Econ 2004;23:839–62.
13. Ivers LC, Cullen KA. Food insecurity: special considerations for women. Am J Clin Nutr 2011;94(Suppl):S1740S–S.
14. Kader M, Perera NKP. Socio-economic and nutritional determinants of low birth weight in India. North Am J Med Sci 2014;6:302–8.
15. Boyd NR, Windsor RA. A meta-evaluation of nutrition education intervention research among pregnant women. Health Educ Behav 1993;20:327–45.
16. Girard AW, Olude O. Nutrition education and counselling provided during pregnancy: effects on maternal, neonatal and child health outcomes. Paediatr Perinat Epidemiol 2012;26(Suppl 1):S191–204.
17. Smith CA. Effects of maternal under nutrition upon the newborn infant in Holland (1944-1945). J Pediatr 1947;30:229–43.
18. Szabo S. The World Bank. 2014 [Available from: http://blogs.worldbank.org/endpovertyinsouthasia/bangladesh-likely-achieve-its-2021-universal-food-security-target.
19. Lee AC, Katz J, Blencowe H, Cousens S, Kozuki N, Vogel JP, Adair L, Baqui AH, Bhutta ZA, Caulfield LE, et al. National and regional estimates of term and preterm babies born small for gestational age in 138 low-income and middle-income countries in 2010. Lancet Glob Health 2013;1:e26–36.
20. Klemm RDW, Merrill RD, Wu L, Shamim AA, Ali H, Labrique A, Christian P, West KP Jr. Low-birthweight rates higher among Bangladeshi neonates measured during active birth surveillance compared to national survey data. Matern Child Nutr 2013;11:583–94.
21. National Institute of Population Research and Training (NIPORT), Mitra and Associates, ICF International. Bangladesh Demographic and Health Survey 2011. Dhaka, Bangladesh, and Rockville, MD: NIPORT, Mitra and Associates, and ICF International; 2013.
22. Islam MM. An evaluation of use of maternal recalled birth size as a proxy measure of birth weight. Matern Child Health J 2014;18:1462–70.
23. Pinstrup-Andersen P. Food security: definition and measurement. Food Sec 2009;1:5–7.
24. WHO recommendations on antenatal care for a positive pregnancy experience. Geneva: World Health Organization; 2016 [available from: http://apps.who.int/iris/bitstream/10665/250796/1/9789241549912-eng.pdf?ua=1.
25. Report of a WHO technical consultation on birth spacing. Geneva: World Health Organization; 2005 [available from: http://apps.who.int/iris/bitstream/10665/69855/1/WHO_RHR_07.1_eng.pdf.
26. Rutstein SO, Johnson K. The DHS Wealth Index. Calverton, MD: ORC Macro; 2004.
27. Diego MA, Field T, Hernandez-Reif M, Schanbergandez S, Kuhn C, Gonzalez-Quintero VH. Prenatal depression restricts fetal growth. Early Hum Dev 2009;85:65–70.
28. Saha KK, Frongillo EA, Alam DS, Arifeen SE, Persson LA, Rasmussen KM. Household food security is associated with infant feeding practices in rural Bangladesh. J Nutr 2008;138:1383–90.
29. Hadley C, Patil CL. Food insecurity in rural Tanzania is associated with maternal anxiety and depression. Am J Hum Biol 2006;18:359–68.
30. Hromi-Fiedler A, Bermúdez-Millán A, Segura-Pérez S, Pérez-Escamilla R. Household food insecurity is associated with depressive symptoms among low-income pregnant Latinas. Matern Child Nutr 2011;7:421–30.
31. King JC. A summary of pathways or mechanisms linking preconception maternal nutrition with birth outcomes. J Nutr 2016;Supplement:1437–44.
32. World Bank. What are the links between agricultural production and food security? http://siteresources.worldbank.org/INTWDRS/Resources/477365-1327599046334/8394679-1327606607122/WDR08_07_Focus_C.pdf (accessed Jul 25, 2017).
33. Zug S. Monga - seasonal food insecurity in Bangladesh - bringing the information together. J Soc Stud 2006;111.
34. Ministry of Food and Disaster Management & World Food Programme-Bangladesh. Food security in Bangladesh. Dhaka, Bangladesh; 2005.
35. Nath NC. Food Security of Bangladesh: Status, Challenges and Strategic Policy Options. 19th Biennial Conference of the BEA; Dhaka, Bangladesh; 2015.
36. National Institute of Population Research and Training (NIPORT), Mitra and Associates, ICF International. Bangladesh Demographic and Health Survey 2014. Dhaka, Bangladesh, and Rockville, MD: NIPORT, Mitra and Associates, and ICF International; 2016.
37. Bangladesh Bureau of Statistics. Report of the Household Income & Expenditure Survey 2010. Dhaka: Statics Division, Ministry of Planning; 2011.
38. Shaheen R, de Francisco A, El Arifeen S, Ekström E-C, Persson LÅ. Effects of prenatal food supplementation on birth weight: an observational study from Bangladesh. Am J Clin Nutr. 2006;83:1355–61.
39. Na M, Mehra S, Christian P, Ali H, Shaikh S, Shamim AA, Labrique AB, Klemm RD, Wu LSF, West KP Jr. Maternal dietary diversity decreases with household food insecurity in rural Bangladesh: a longitudinal analysis. J Nutr 2016;146:2109–16.
40. Titaley CR, Dibley MJ, Agho K, Roberts CL, Hall J. Determinants of neonatal mortality in Indonesia. BMC Public Health 2008;8:232.