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

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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.

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

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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 yrs. 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 yrs 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 yrs 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 categorical 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 categorical 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 February 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 non-convergence. 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/m²) <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 ($n = 8588$)

| Factors                              | $n$ (weighted) | Relative frequency, % | Mean ± SD | Small birth size, $^2$ % |
|--------------------------------------|---------------|-----------------------|-----------|-------------------------|
| Food security                        |               |                       |           |                         |
| Food secure                          | 5537          | 64.3                  |           | 15.7                    |
| Food insecure                        | 3069          | 35.7                  |           | 20.3                    |
| Sex of child                         |               |                       |           |                         |
| Male                                 | 4416          | 51.2                  |           | 15.3                    |
| Female                               | 4214          | 48.8                  |           | 19.5                    |
| Birth interval, mo                   |               |                       |           |                         |
| <33                                  | 1504          | 17.4                  |           | 16.8                    |
| ≥33                                  | 7126          | 82.6                  |           | 17.5                    |
| Mother’s age at birth, y             |               |                       |           |                         |
| <20                                  | 2770          | 32.1                  |           | 18.9                    |
| 20–34                                | 5482          | 63.5                  |           | 16.5                    |
| >34                                  | 378           | 4.4                   |           | 18.6                    |
| Mother’s height, cm                  |               |                       |           |                         |
| <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$^2$          |               |                       |           |                         |
| Thin                                 | 2332          | 27.0                  |           | 19.8                    |
| Normal                               | 5137          | 59.5                  |           | 16.8                    |
| Overweight                           | 1161          | 13.5                  |           | 14.7                    |
| Mother’s anemia status$^4$           |               |                       |           |                         |
| 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                   |               |                       |           |                         |
| 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                   |               |                       |           |                         |
| 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 |           |                       |           |                         |
| No                                   | 3396          | 40.0                  |           | 19.2                    |
| Yes                                  | 5095          | 60.0                  |           | 16.2                    |
| Mother’s exposure to television      |               |                       |           |                         |
| Not at all                           | 3597          | 41.7                  |           | 17.7                    |
| ≤1 time/wk                           | 5032          | 58.3                  |           | 17.1                    |
| Father’s education                   |               |                       |           |                         |
| 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                               |               |                       |           |                         |
| 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 2  Household experience of specific food insecurity-related conditions

| Factors                        | 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)                                 |

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-year 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 3  Effects of household food security on birth size of infants

| Factors                                      | Crude OR (95% CI) | P value | Adjusted OR (95% CI) | 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   | 1.22 (1.21, 2.21)    | 0.001*  |
| 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    | —                    |         |

*Significant at P < 0.05; **Significant at P < 0.001. ANC, antenatal care.

2The 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.

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