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# DETERMINANTS OF NUTRITIONAL STATUS AMONG UNDER-FIVE CHILDREN IN RURAL BANGLADESH: A QUANTITATIVE ANALYSIS USING MULTILEVEL APPROACH

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## ABSTRACT

The present study examines the differential impact of some demographic, socioeconomic and health-related factors on the nutritional status among under-five children in rural Bangladesh using a nationally representative Bangladesh Demographic and Health Survey (BDHS) 2011 data. The BDHS follows a hierarchical data structure because the survey is based on two-stage stratified sampling. Two-level random intercept binary logistic regression models were used to capture the unobserved heterogeneity between clusters (communities) and to identify the determinants of under-five children's malnutrition. The analyses found that 16% of the children were severely stunted and 26% were moderately stunted. Among the under-five children, 4% were severely wasted and 12% were moderately wasted. Furthermore, 11% of the children were severely underweight and 28% were moderately underweight. The potential factors having significant association with malnutrition were found to be division, child age in month, sex of child, twin child, preceding birth interval, child birth size, religion, mother's and father's education, wealth index, household size, age of household head at first child birth, sources of drinking water and suffer from fever and diarrhea. Significant community-level variations were observed in the analyses which emphasis the need for extra attention on the poor performing communities. Specific policy recommendations have been suggested for the improvement of nutritional status of under-five children in rural Bangladesh.

**Key words:** Nutritional status, BDHS, under-five children, Multilevel Modeling, rural Bangladesh.

## I. INTRODUCTION

Malnutrition is a persistent child health problem in the developing world and one of the major causes of morbidity and mortality among under-five children (WHO, 2000; Martorell et al., 1992). Also, malnutrition is a significant cause of children's abnormal physical and intellectual improvement (Das and Rahman, 2011). The nutritional status of children under the age of five years is of particular concern because the early years of life are very important for optimal growth, mental development and future prospects of the community (Preschulek *et al.,* 1999). Inadequate physical growth and mental development, as well as severe illness and disability in adult life, occur due to nutritional deficiencies, especially at childhood. Significant contributing factors for child morbidity and mortality, poor nutritional status during childhood also have implication for adult economic attainment and healthiness (Kabubo-Mariara et al., 2006; Victora et al., 2008).

There exists enormous literature covering almost every country of the globe that deal with the status and determinants of child malnutrition (for example, Kinyoki et al., 2015; Ortiz et al., 2013; Aguayo *et al.,* 2012; Masibo and Makaka, 2012; Corsi *et al.,* 2011; Taguri *et al.,* 2008; Assis *et al.,* 2007; Alom *et al.,* 2012; Rahman *et al.,* 2009; Hong *et al.,* 2006; Islam *et al.,* 2010; Kiess *et al.,* 2000; Rajaretnam and Hallad, 2000; Rayhan and Khan, 2006; Shrimpton and Yongyout, 2003; Smith and Haddad, 2000). These studies represent different cultural settings and socio-

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economic context and together they reveal complex relationships between the nutritional status of under-five children and different risk factors.

Tharakan and Suchindran (1999) examined the status and determinants of child malnutrition in rural Kerala using a national cross-sectional data. Their study identified a number of social, cultural, economic, biological and morbidity factors that are significantly associated with child malnutrition. A study on child acute malnutrition in Bangladesh using BDHS 2000 data based on multinomial logistic regression reveals that mother's BMI and media exposure, child's age and birth size, and respiratory sickness in childhood were significantly related with both severe and moderate wasting (Rahman, *et al.,* 2009). Alom *et al.* (2012) investigated under-five child malnutrition in Bangladesh in terms of stunting, wasting and underweight using BDHS 2007 data. They identified child age, father's education, mother's education, place of delivery, family wealth index and division as important determinants of malnutrition. Also, significant community-level variations were observed.

Globally, more than one quarter (26%) of children under-five years of age were stunted in 2011– roughly 165 million children worldwide. In Sub-Saharan Africa, 40% of children under-five years of age are stunted while in South Asia, 39% are stunted (UNICEF, 2012). In South Asia, the second highest infant and child mortality rate were observed in Pakistan, where about 32% children were malnourished (Mahmood *et al.,* 2016). Badake *et al.* (2014) reveal that 39%, 7.1% and 18.1% children among under-five years are stunted, wasted and underweight respectively in Mbeere South District in Kenya. More alarmingly, in a developing country like Bangladesh, the prevalence of malnutrition among under-five children is a chronic health problem. However, after many successful programme interventions, the nutritional status of under-five children in Bangladesh has improved to some extent since 2004 but is still facing a distressing level of child nutritional deficiency. According to BDHS (2011) the percentage of stunting, wasting and underweight of children under-five years were respectively 42.7, 16.0 and 38.7 in rural areas; 36.2, 14.0 and 28 in urban areas; and 41.3, 15.6, 36.4 in national level indicating a significant gap in nutritional status among under-five children and children from rural areas are suffering the most. Moreover, there exist different cultural practices, religious rituals and social taboos in the rural areas, which are absent in the urban areas, that have a direct link with dietary habit of the rural community, consequently impacting nutritional status (Ansari et al., 2014; Barnett et al., 2006). This emphasizes the need for in-depth analysis of the nutritional status of the under-five children in rural Bangladesh.

This study aims to identify the determinants of malnutrition among under-five children in rural Bangladesh using Bangladesh Demographic and Health Survey (BDHS). The BDHS is a multistage cluster survey has hierarchy in the data where individuals are nested into the households and households are nested into the communities (PSU), hence the need for the use of multilevel regression modeling is identified (Alom *et al.,* 2012; Islam, 2010). There is evidence that the likelihood of community effect is high in developing countries (Islam, 2010). Furthermore, the community effect in the rural areas has been explored less and demand an in-depth study. It is expected that this study will fill up the gaps in this respect.

## II. METHODOLOGY

### Data

The present study uses Bangladesh Demographic and Health Survey (BDHS) 2011 data. The National Institute of Population Research and Training (NIPORT) of the Ministry of Health and Family Welfare is the main authority of BDHS data. The BDHS is a nationally representative survey designed to provide information on basic national indicators of social improvement including nutritional status of mother and children, childhood mortality, fertility, maternal and child health, awareness of AIDS and domestic violence. To ensure greater precision the two-stage stratified random sampling techniques were used during the survey where each of the seven administrative divisions of Bangladesh (Barisal, Chittagong, Dhaka, Khulna, Rajshahi, Rangpur and Sylhet) is divided into a number of clusters. In the first stage, the mauza in rural strata was considered as primary sampling units (PSUs) and in the second stage, households from each PSU were selected using a systematic sampling scheme. A primary sampling unit (PSU) is usually a natural cluster of households. The BDHS data are hierarchical due to its formation where individuals are being nested into PSUs, and PSUs into divisions. In the 2011 BDHS, a total of 10,996 ever-married women of age 15 – 49 from the selected households were interviewed to collect data on fertility, family planning, child and maternal health. In our study, we use 5273 under-five children generated from the women sample in rural Bangladesh to assess the nutritional status as well as its associated factors.

### Measures of child nutritional status

The Z-score method is the most popular and common method of measuring child nutritional status (WHO, 1986; Cogill, 2003). The Z-scores are calculated on the basis of different anthropometric measures such as age, height and weight along with WHO Child Growth Standards (WHO, 2006). The formula for the computation of Z-scores is as follows:

$$Z_{\text{score}} = \frac{\text{Individuals height or weight} - \text{median of the reference population}}{\text{Standard deviation of the reference population}}$$

In this study three widely used measures of malnutrition, namely stunting, wasting and underweight are considered. The standardized height-for-age (HAZ), weight-for-height (WHZ) and weight-for-age (WAZ) are measures of stunting, wasting and underweight, respectively. The stunting reflects chronic malnutrition among children aged 0 to 59 months while wasting reflects child acute malnutrition. Underweight reflects chronic or acute undernutrition or a combination of both (BDHS, 2011).

### Determination of child nutritional status

The main goal of this study is to examine the factors related to the response variables (e.g., stunting, wasting and underweight). In the survey data set the dependent variable (child nutritional status) is categorized into three groups as follows: (i) severely malnourished if *Z*-score is less than -3.0, (ii) moderately malnourished if *Z*-score is between -3.0 to -2.01, and (iii) healthy if Z-score is greater than or equal to -2.0. However, for the convenience in the regression modelling the dependent variables are re-coded into two groups (binary) because some of the higher categories have fewer observations. The categories are as follows: (i) 1 = child is malnourished if *Z*-score is less than -2.00 and (ii) 0 = child is not malnourished if *Z*-score is greater than or equal to -2.00 (reference category). The primary preference of explanatory variables for this study was based on previous other studies on the factors influencing children's nutritional status. The independent variables used in the study are division, child age in month, sex of child, twin child, birth order, birth interval, religion, mother's education, father's education, mother's age at first child birth, age of household head at first child birth, toilet facility, sources of drinking water, wealth index, child received vitamin A, place of delivery, total children ever born, household size, child size at birth, child suffered from fever, cough and diarrhoea, had television, had radio, and refrigerator and access to electricity. 2.3.1 Two-level random intercept binary logistic regression model.

It is very likely that the cluster or community (PSU) effect on the response variable will be present when there is a hierarchical data structure in the survey, for example, BDHS 2011. The traditional logistic regression ignoring such cluster effect is inappropriate as the standard errors of regression coefficients are underestimated leading to the significance of a regression coefficient that could be ascribed to likelihood. This may instigate wrong policy formulation (for example, see Khatun *et al.,* 2012). In this context, to overcome this problem a multilevel logistic regression model containing both fixed effects and random effects that attempts to capture the unobserved heterogeneity between clusters is commonly used (Pinheiro and Bates, 2000; Goldstein, 2003; Demidenko, 2004). The use of appropriate multilevel model provides efficient estimates and the policies devised on the basis of these are reliable. In addition, the significance and extent of the community effect help to find if there is any community that is performing poorly.

In the general case, the two-level random intercept binary logistic regression model is the expansion of the single-level binary logistic regression model (see for details, Goldstein, 2003). Let a binary response variable $Y_{ij}$ be 'child malnutrition' (1 = if child $i$ in community $j$ is malnourished, 0 otherwise). The two-level random intercept binary logistic regression model considering children at level-1 and communities (PSU) at level-2 can be written as follows:

$$\text{logit}(\pi_{ij}) = \log\left(\frac{\pi_{ij}}{1-\pi_{ij}}\right) = \beta_{0j} + \sum_{k=1}^{m} \beta_k X_{ijk}; \qquad i = 1,2,\ldots,n_j, j = 1,2,\ldots,d$$

$$\text{with } \beta_{0j} = \beta_0 + u_{oj}; \quad u_{0j} \sim iidN(0, \sigma_{u0}^2),$$

where $\pi_{ij} = \Pr(Y_{ij} = 1)$ is the probability that the child $i$ in community $j$ is malnourished, $X_{ijk}$ is the values of $m$ explanatory variables for child $i$ in community $j$ and $\beta_k$ is a vector of regression coefficients to be estimated. Also, $\beta_0$ is a fixed component and the random cluster-specific effect $u_{0j}$ is assumed to be independently and identically normally distributed. To capture the unobserved variation not explained by the explanatory variables, the random cluster-specific (PSU) effects are taken. The rejection of the null hypothesis $H_0 : \sigma_{u0}^2 = 0$, indicates that there is a significant community effect in the model, meaning that the extent of malnutrition will not be the same for the children from different community with the same set of characteristics. Moreover, assuming different values for $u_{oj}$, the effects of the community-specific component on the response variable can be explored in relation to other explanatory variables due to the additive nature of the model.

The two-level random intercept binary logistic regression model is fitted using STATA 14.0 software considering only the independent variables found significant in the analyses and variables found significant at this stage are kept in the final models. The possibility of multicollinearity and confounding has been explored too. The possible interaction effects were tested and are reported where found.

## III. RESULT AND DISCUSSION

The nutritional status of under-five children in rural Bangladesh assessed by stunting, wasting and underweight is shown in Figure 1. The study found that about 16% children were severely stunted, 26% were moderately stunted and the rest were healthy. On the other hand, 11% and 28% children were severely and moderately underweight respectively. The percentages for wasting were 4% and 12% for severely and moderately wasted respectively.

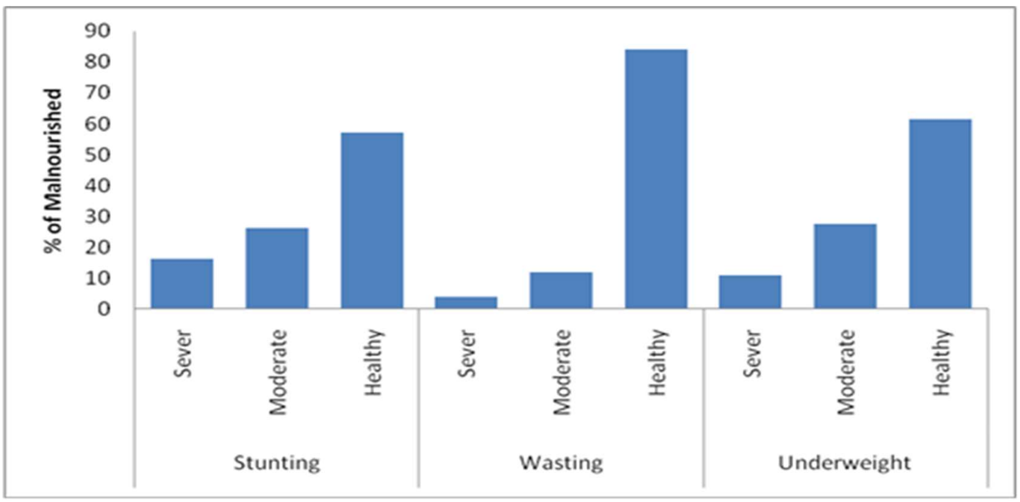


Figure 1. Prevalence of malnutrition among the under-five children in rural Bangladesh

**Determinants of stunting (child chronic malnutrition)**

Table 1 represents the significant determinants that have been found by the two-level random intercept binary logistic regression model for stunting in rural Bangladesh. The results reveal that children from Sylhet division were 1.31 times more likely to be stunted, while children from Khulna division were 0.69 times less likely to be stunted compared to the children from Barisal division. Similarity was observed by Alom *et al.* (2012) for Khulna division but not for Sylhet division. The reason is that Alom *et al.* (2012) was based on national level analysis while the current study focuses on rural areas only. With the increase in child age, the likelihood of stunting seems to increase. However, there is a diminishing rate observed as age increases. For example, children of age between 12-23 months were 4.17 times, whereas children aged 24-35 months were 3.91 times more likely to be stunted compared to the children age less than 11 months. This may be due to the fact that in rural areas practice of supplementary food use is not a regular case. For that reason, children experience a nutritional deficiency after age 11 months which however seem to be overcome as age increases. Our findings are more or less consistent with the results of Mishra and Retherford (2000) and Ortiz *et al*. (2013). Though not significant, like Kinyoki *et al*. (2015) it appeared that female children in rural areas were more likely to be stunted than their male counterparts. If the child is a twin of the second of multiple births the likelihood of being stunted was 2.34 times more than the child from a single birth outcome. Obviously, it is linked with maternal health related to single versus multiple births and the subsequent impact on child health due to lower birth weight (Sharmin and Islam, 2016). As expected if the preceding birth interval is more than two years the child is less likely to be stunted. The result shows that when preceding birth interval was more than two years the likelihood of a child being stunted was 0.78 times less compared to a child with preceding birth interval less than two years. Almost consistent results were reported by studies conducted in Bangladesh and India (Sharmin and Islam, 2016; Rayhan and Khan, 2006; Rajaretnam and Hallad, 2000).

Table 1. Two-level random intercept binary logistic regression estimates of the effect of different socio-economic and demographic characteristics on stunting among under-five children in rural Bangladesh.

| Independent Variable | Categories | $\hat{\beta}$ (SE) | OR [95% CI] |
|---|---|---|---|
| Intercept | | $-0.73^{***}$ (0.22) | 0.48 [0.31, 0.74] |
| Division (ref: Barisal) | Chittagong | -0.15 (0.13) | 0.86 [0.66, 1.10] |
| | Dhaka | -0.05 (0.13) | 0.95 [0.73, 1.23] |
| | Khulna | $-0.37^{***}$ (0.14) | 0.69 [0.52, 0.92] |
| | Rajshahi | $-0.51^{***}$ (0.14) | 0.60 [0.45, 0.79] |
| | Rangpur | -0.15 (0.13) | 0.86 [0.66, 1.12] |
| | Sylhet | $0.27^{**}$ (0.14) | 1.31 [1.01, 1.71] |
| Child's age in month (ref:≤11) | 12-23 | $1.43^{***}$ (0.11) | 4.17 [3.33, 5.21] |
| | 24-35 | $1.36^{***}$ (0.11) | 3.91 [3.13, 4.86] |
| | 36-47 | $1.31^{***}$ (0.11) | 3.70 [2.98, 4.59] |
| | 48-59 | $1.05^{***}$ (0.11) | 2.85[2.28, 3.55] |
| Sex of child (ref: Female) | Male | -0.02 (0.06) | 0.98 [0.87, 1.10] |
| Twin childs (ref: Single Birth) | 1st of multiple | 0.32 (0.39) | 1.38 [0.65, 2.96] |
| | 2nd of multiple | $0.85^{***}$ (0.35) | 2.34 [1.18, 4.67] |
| Preceding birth interval (ref:<2 years) | More than 2 years | $-0.24^{***}$ (0.07) | 0.78 [0.67, 0.89] |
| Religion (ref: Non-Muslim) | Muslim | $0.26^{**}$ (0.11) | 1.30 [1.05, 1.61] |
| Mother's education(ref: No Education) | Primary | -0.09 (0.09) | 0.91 [0.77, 1.09] |
| | Secondary | $-0.17^{*}$ (0.10) | 0.85 [0.69, 1.03] |
| | Higher | $-0.50^{**}$ (0.20) | 0.61 [0.41, 0.89] |
| Father's education(ref: No Education) | Primary | -0.03 (0.08) | 0.97 [0.83, 1.14] |
| | Secondary | $-0.24^{***}$ (0.08) | 0.79 [0.67, 0.93] |
| | Higher | $-0.27^{**}$ (0.14) | 0.764 [0.59, .99] |
| Wealth index(ref: Poorest) | Poorer | $-0.34^{***}$ (0.09) | 0.71 [0.60, 0.85] |
| | Middle | $-0.51^{***}$ (0.10) | 0.60 [0.50, 0.72] |
| | Richer | $-0.68^{***}$ (0.11) | 0.51 [0.41, 0.63] |
| | Richest | $-1.17^{***}$ (0.15) | 0.31 [0.23, 0.42] |
| HH size (ref: ≤6 members) | 7+ members | $0.20^{***}$ (0.07) | 1.23 [1.06, 1.42] |
| Random Effect SD: PSU | | $0.31^{***}$ (0.06) | [0.22, 5.46] |

Note: SE, CI, OR and SD denote standard error, confidence interval, odds ratio and standard deviation respectively. *p < 0.10; **p < 0.05; ***p < 0.01.

The children from Muslim families were 1.30 times more likely to be stunted compared to children from non-Muslim families. The reason may be the extended period of isolation of the mother and infant soon after birth, restriction of certain food items and traditional health practices (religious, herbal) offered to the infants and mothers, and in some cases avoidance of colostrums for infants compared their non-Muslim counterparts (Ansari *et al.,* 2014; Barnett *et al.,* 2006). The likelihood of stunting decreases with the increase of parent's education. For example, the children of mother and father having secondary level education were 0.85 and 0.79 times respectively less likely to be stunted than the children of non-educated parents. Similarity was observed by Taguri *et al.* (2008) in Libya and Alom *et al.* (2012) in Bangladesh. Furthermore, wealthy households were less likely to have stunted children than poor households. The results obtained from the analysis reveal that the children from the richest families were 0.31 times less likely to be stunted than the children from the poorest families. This result is consistent with the findings of Vella *et al.* (1994) in Uganda and Alom *et al.* (2012) in Bangladesh. Children from bigger families (> 6 members) were more likely to suffer from stunting compared to children from smaller families (OR = 1.23). The obvious reason is that as the family size increases the per capita consumption of food tends to decrease. A study by Kinyoki *et al.* (2015) in Somalia conforms to the findings.

Significant community effect (SD = 0.31) was observed in the model, meaning that children from different communities having similar characteristics will exhibit different nutritional status. Moreover, the additive nature of the model indicates that a one standard deviation change in the community random effect has a higher influence on stunting than the children from Sylhet division $(\hat{\beta} = 0.27)$, preceding birth interval more than two years $(\hat{\beta} = -0.24)$, religion $(\hat{\beta} = 0.26)$, mother having secondary education $(\hat{\beta} = -0.17)$, father having secondary and higher education $(\hat{\beta} = -0.24, -0.27)$ and household size $(\hat{\beta} = 0.20)$. In this context, policy planners can achieve more to improve stunting among the children of that community by focusing on the community-specific characteristics (e.g. food habits and composition, and social taboo) than giving emphasize on other personal, familial, and contextual characteristics listed above.

**Determinants of wasting (child acute malnutrition)**

The findings of the two-level logistic regression model for wasting indicate that children from Sylhet division were 1.49 times more likely to be wasted compared to the children from Barisal division (Table 2). At a national level study, Alom et al. (2012) did not find any significant effect of division. The current study on rural areas highlights that there may be significant differences in the food behaviour and consumption pattern among the children from Sylhet division and Barisal division. With the increase in child age from 36 months the likelihood of wasting seems to increase. Children aged 36-47 months were 1.25 times, whereas children aged 48-59 months were 1.27 times more likely to be wasted compared to the children aged less than 11 months. A similar pattern was observed by Masibo and Makoka (2012).

The likelihood of wasting decreases with the increase of father's education. For example, the children of father having higher level education were 0.72 times less likely to be wasted than the children of non-educated father. Studies (Alom et al., 2012; Das and Gulshan, 2017) at national level in Bangladesh did not report to have a significant effect of father's education on wasting. Age of household head at first birth between 30-40 years was 0.82 times less likely to be wasted compared to the household head aged less than 30 years. Previous studies conducted in Bangladesh did not consider this variable in their modelling practices. However, this variable seems to have a significant impact on wasting in rural Bangladesh. This is closely associated with lesser awareness of balance diet and experiences related to health practices among relatively young household heads prevailing in rural Bangladesh.

Children of families having access to tube-well water and water from other sources (pond, river, rainfall, etc.) were 2.19 times and 3.17 times respectively more likely to be wasted compared to the children of family having access to own supply water. The findings reiterate the impact of unsafe water on child health in terms of spreading dirrhoea and other water borne diseases, consequently increasing wasting among the children (WHO, 2014; Masibo and Makoka, 2012). Children with larger birth size were significantly less likely to be wasted. Masibo and Makoka (2012), and Sharmin and Islam (2016) reported the same for Kenya. Children who suffered from fever were more likely to be wasted. Akombi *et al*. (2017) observed the same in Nigeria.

Table 2. Two-level random intercept binary logistic regression estimates of the effect of different socio-economic and demographic characteristics on wasting among under-five children in rural Bangladesh

| Independent variables | Categories | $\hat{\beta}$ (SE) | OR [95% CI] |
|---|---|---|---|
| Intercept | | $-3.12^{***}$ (0.51) | 0.04 [0.02, 0.12] |
| Division (ref: Barisal) | Chittagong | 0.22 (0.17) | 1.25 [0.90, 1.74] |
| | Dhaka | 0.17 (0.17) | 1.19 [0.85, 1.67] |
| | Khulna | 0.18 (0.19) | 1.19 [0.83, 1.71] |
| | Rajshahi | 0.23 (0.18) | 1.26 [0.88, 1.79] |
| | Rangpur | -0.06 (0.18) | 0.94 [0.66, 1.35] |
| | Sylhet | $0.40^{**}$ (0.17) | 1.49 [1.06, 2.09] |
| Child age (ref: ≤11 months) | 12-23 | 0.17 (0.14) | 1.19 [0.91, 1.56] |
| | 24-35 | 0.05 (0.14) | 1.05 [0.80, 1.37] |
| | 36-47 | $0.22^{*}$ (0.13) | 1.25 [0.96, 1.62] |
| | 48-59 | $0.24^{*}$ (0.13) | 1.27 [0.98, 1.65] |
| Sex of child (ref: Female) | Male | -0.01 (0.08) | 0.99 [0.85, 1.15] |
| Father's education (ref: No education) | Primary | -0.16 (0.10) | 0.86 [0.70, 1.05] |
| | High School | -0.09 (0.11) | 0.91 [0.74, 1.13] |
| | Higher | $-0.34^{*}$ (0.18) | 0.72 [0.49, 1.03] |
| HH age at first birth (ref: <30 yr) | 30-40 | $-0.19^{*}$ (0.11) | 0.82 [0.66, 1.02] |
| | 40-50 | -0.12 (0.13) | 0.89 [0.69, 1.14] |
| | 50-60 | -0.22 (0.15) | 0.79 [0.59, 1.07] |
| | >60 | 0.01 (0.14) | 1.00 [0.76, 1.33] |
| Source of drinking water (ref: Supply) | Tubewell | $0.79^{**}$ (0.39) | 2.19 [1.02, 4.69] |
| | Other | $1.15^{***}$ (0.44) | 3.17 [1.39, 7.52] |
| Child Birth Size (ref: Large) | Average | $0.37^{***}$ (0.12) | 1.45 [1.15, 1.84] |
| Fever (ref: No) | Yes | $0.26^{***}$ (0.08) | 1.29 [1.11, 1.51] |
| Random Effect SD: PSU | | $0.36^{***}$ (0.07) | [0.24, 0.53] |

Note: SE, CI, OR and SD denote standard error, confidence interval, odds ratio and standard deviation respectively. $^{*}p < 0.10$; $^{**}p < 0.05$; $^{***}p < 0.01$.

Significant community effect (SD = 0.36) was observed in the model. A one standard deviation change in the community random effect has a higher influence on wasting than the children belonged to age groups 36-47 and 48-59 months $(\hat{\beta} = 0.22, 0.24)$, father having higher education $(\hat{\beta} = -0.34)$, age of household head at first child birth $(\hat{\beta} = -0.19)$ and child suffered from fever $(\hat{\beta} = 0.26)$. These suggest that addressing some of the poor performing communities may result faster achievement in overcoming wasting than investing in some specific policy variables.

**Determinants of underweight (child undernutrition)**

The results from two-level logistic regression model for underweight reveal that children from Sylhet division were 1.39 times more likely to be underweight, while children from Khulna division and Rangpur division were 0.77 times and 0.78 times respectively less likely to be underweight compared to the children from Barisal division (Table 3). This result is partially approved by Alom et al. (2012) for Khulna division and by Sharmin and Islam (2016) for Sylhet division. An increasing rate was observed for underweight for increase in child age. For example, children of age groups 12-23, 24-35 and 36-47 months were 2.37, 2.82 and 3.06 times respectively more likely to be underweight, compared to the children aged less than 11 months. This is related to the prevailing poverty and a biased food habit towards calorie than protein and other necessary nutrients in rural Bangladesh and this seems to have a cumulative and sustaining effect on child's weight. Assis et al. (2007) also observed a similar pattern in Northeastern Brazil. The analyses show that sex of child had a significant effect on underweight. Male children were 0.83 times less likely to be underweight compared to their female counterpart. Sharmin and Islam (2016) found the opposite in their study based on a national level study. However, our result is still acceptable for the obvious reason that there prevails discrimination in food distribution by sex, especially negatively biased towards female children, in rural communities (Pande, 2003). It has been observed that if the preceding birth interval is more than two years, the child is less likely to be underweight. The result shows that when preceding birth interval was more than two years the likelihood of a child being underweight was 0.85 times less compared to a child with preceding birth interval less than two years. Like other studies (Masibo and Makoka, 2012; Alom *et al.,* 2012), the likelihood of underweight decreases with the increase of parent's education. For example, the children of mother and father having secondary level education were 0.83 and 0.84 times less likely to be underweight respectively than the children of non-educated parents. The study reveals that children of families taking drinking water from an unsafe source were 2.22 times more likely to be underweight compared to children having water from a safe source like own supply water. Masibo and Makoka (2012) reported the same in Kenya. Furthermore, wealthy households were less likely to have underweight children than poor households. The results obtained from the analysis reveal that the children from the richest families were 0.44 times less likely to be underweight than the children from the poorest families. This result is consistent with the findings of Vella *et. al.,* 1994 and Alom *et al.,* 2012. A child having average birth size was 1.81 times more likely to be underweight than child having larger birth size. Sharmin and Islam (2016) observed a similar relationship in Bangladesh. Child suffered from fever and diarrhoea was 1.29 and 1.32 times respectively more likely to be underweight compared to their counterparts. The results conform to the findings by Akombi *et al.* (2017) in Nigeria.

Significant community effect (SD = 0.33) was observed in the two-level random intercept model for underweight. It is clearly evident that a one standard deviation change in the community random effect has a higher influence on underweight than the Khulna and Rangpur divisions $(\hat{\beta} = -0.27, -0.25)$, child sex $(\hat{\beta} = -0.18)$, preceding birth interval $(\hat{\beta} = -0.17)$, mother having secondary education $(\hat{\beta} = -0.19)$, father having secondary education $(\hat{\beta} = -0.17)$, poorer households $(\hat{\beta} = -0.26)$, child suffered from fever $(\hat{\beta} = 0.25)$, and child suffered from diarrhoea $(\hat{\beta} = 0.28)$. Policy planners may address the poor performing communities to achieve more in terms of achieving nutritional targets.

Table 3. Two-level random intercept binary logistic regression estimates of the effect of different socio-economic and demographic characteristics on underweight among under-five children in rural Bangladesh

| Independent variable | Categories | $\hat{\beta}$ (SE) | OR [95% CI] |
|---|---|---|---|
| Intercept | | -1.64$^{***}$ (0.34) | 0.19 [0.09, 0.38] |
| Division (Ref: Barisal) | Chittagong | 0.09 (0.13) | 1.09 [0.84, 1.41] |
| | Dhaka | 0.05 (0.14) | 1.06 [0.81, 1.38] |
| | Khulna | -0.27$^{*}$ (0.15) | 0.77 [0.57, 1.03] |
| | Rajshahi | -0.12 (0.14) | 0.89 [0.67, 1.18] |
| | Rangpur | -0.25$^{*}$ (0.14) | 0.78 [0.59, 1.03] |
| | Sylhet | 0.33$^{**}$ (0.14) | 1.39 [1.06, 1.82] |
| Child age (Ref: ≤11 month) | 12-23 | 0.87$^{***}$ (0.11) | 2.37 [1.93, 2.92] |
| | 24-35 | 1.04$^{***}$ (0.11) | 2.82 [2.29, 3.47] |
| | 36-47 | 1.12$^{***}$ (0.10) | 3.06 [2.51, 3.74] |
| | 48-59 | 1.06$^{***}$ (0.10) | 2.89 [2.36, 3.54] |
| Sex of child (Ref: Female) | Male | -0.18$^{***}$ (0.06) | 0.83 [0.74, 0.94] |
| Preceding birth interval (Ref: < 2 years) | More than 2 years | -0.17$^{**}$ (0.07) | 0.85 [0.74, 0.97] |
| Mother's education (Ref: No education) | Primary | -0.05 (0.09) | 0.95 [0.80, 1.13] |
| | Secondary | -0.19$^{*}$ (0.10) | 0.83 [0.68, 1.00] |
| | Higher | -0.39$^{*}$ (0.21) | 0.68 [0.45, 1.02] |
| Father's education (Ref: No education) | Primary | -0.06 (0.08) | 0.94 [0.80, 1.11] |
| | Secondary | -0.17$^{**}$ (0.09) | 0.84 [0.71, 0.99] |
| | Higher | -0.43$^{***}$ (0.14) | 0.65 [0.49, 0.86] |
| Source of drinking water (Ref: Supply) | Tubewell | 0.50$^{*}$ (0.27) | 1.65 [0.98, 2.77] |
| | Other | 0.79$^{**}$ (0.32) | 2.22 [1.18, 4.19] |
| Wealth index (Ref: Poorest) | Poorer | -0.26$^{***}$ (0.09) | 0.77 [0.65, 0.91] |
| | Middle | -0.44$^{***}$ (0.10) | 0.64 [0.53, 0.79] |
| | Richer | -0.76$^{***}$ (0.14) | 0.47 [0.36, 0.61] |
| | Richest | -0.82$^{***}$ (0.21) | 0.44 [0.29, 0.66] |
| Child birth size (Ref: Large) | Average | 0.59$^{***}$ (0.09) | 1.81 [1.51, 2.16] |
| Fever (Ref: No) | Yes | 0.25$^{***}$ (0.06) | 1.29 [1.14, 1.46] |
| Diarrhea (Ref: No) | Yes | 0.28$^{**}$ (0.14) | 1.32 [1.01, 1.74] |
| Random Effect SD: PSU | | 0.33$^{***}$(0.05) | [0.24, 0.45] |

Note: SE, CI, OR and SD denote standard error, confidence interval, odds ratio and standard deviation respectively. *p < 0.10; **p < 0.05; ***p < 0.01.

On the final remark, it may be suggested that the three measures of malnutrition have different associations with child age (Figure 2). Probability of stunting and underweight seem to shoot up during the first year of child's age and decrease gradually. On the other hand, probability of wasting seems to follow a linear trend. The former two may be associated with food habit, composition and frequency, while the later may be associated with the prevailing poverty situation in rural Bangladesh. Similar results were observed by Olack *et al.* (2011) in Nirobi, Kenya.

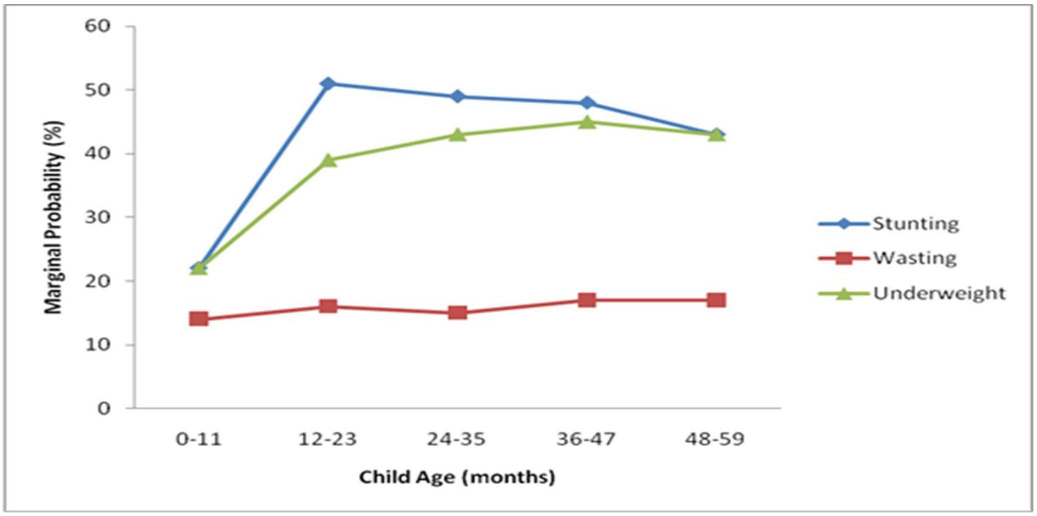


Figure 2. Marginal probability of malnutrition of under-five children by age.

## *IV.* CONCLUSION AND POLICY RECOMMENDATION

This study investigated the nutritional status of under-five children in rural Bangladesh using a nationally representative BDHS 2011 dataset. Three widely used anthropometric measures, namely stunting, wasting and underweight were utilized to assess the nutritional status of children under-five. The analyses revealed that among the study children from rural areas, the prevalence of stunting, wasting and underweight were 43%, 16% and 39% respectively, which are above the prevalence's at urban and national level. These indicate that children from rural areas are suffering the most and require immediate policy intervention.

This study identified several risk factors that were associated with child malnutrition using two-level random intercept binary logistic regression model. In the context of rural Bangladesh, this is the first study which used such relatively innovative approach and is an additional contribution of this paper. The significant determinants of stunting were found to be division, child age in month, twin child, preceding birth interval, religion, mother's education, father's education, wealth index, and household size. Also, division, child age in month, father's education, age of household head at first child birth, sources of drinking water, child birth size and child suffered from fever are significantly associated with wasting. Furthermore, potential factors having significant association with underweight were division, child age in month, sex of child, preceding birth interval, father's education, mother's education, sources of drinking water, wealth index, child birth size and child suffered from diarrhoea. It appears from the study that specific interventions are required for different measures of malnutrition.

The policymakers should address the risk factors identified in this study for the improvement of children's nutrition and health, especially, i) improving the education level of parents, ii) expanding the preceding birth interval by motivational campaign and iii) help the mothers achieving optimum child birth size by proper antenatal care service facilities during pregnancy and improving access to health services and nutrition education. Together, these will help achieve a better nutritional status among under-five children in rural Bangladesh. Significant community effects were found in the models for all the measures of malnutrition. This research recommends that additional programme support, besides the national level programme, be offered for different communities to overcome the problem of malnutrition. The study also argues that sometimes more can be achieved by addressing only the community variations. Rural Bangladesh exhibits different socio-cultural setup with the coexistence of traditional health practices and food behaviour together with embedded taboo, hence demand specific and tailor-made interventions to combat the problem of malnutrition.

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