# Child Stunting

*By* Mowmi et al

# Prevalence of Stunting and Associated Factors among under-5 children in Bangladesh: An Application of Multilevel Mixed-effects Logistic Regression Models.

## Abstract

**Background:** One of the most well-established risk indicators of poor child development is stunting. Although several studies were conducted on this issue, extensive analyses are still required in developing countries to understand stunting. We sought to evaluate the prevalence of stunting in children under the age of five, and the associated factors using a multilevel mixed-effects logistic regression model.

**Methods:** We used nationally representative data from the Bangladesh Demographic and Health Survey (BDHS) 2017-18. First, we conducted a multivariable binary logistic regression model and then multilevel mixed-effects logistic regression to identify the risk factors of child stunting at single-level and multilevel, respectively.

**Result:** We found that most of the stunted children (38.54%) were found in poor family settings in Bangladesh, and the rate of stunting was higher in rural areas (32%). The most vulnerable age group (24-35) months children had found 3.03 times (OR: 3.03, 95% CI: 2.42- 3.80) higher chance of stunting in multilevel binary logistic regression model. Furthermore, division, parents' education level, household head's occupation, and wealth index were significantly associated with stunting.

**Conclusion:** The prevalence of stunting is still very high in Bangladesh. The study found child stunting was significant in both individual and regional levels. Most importantly, although Bangladesh achieved a good literacy level, educated parents are playing a vital role in reducing child malnutrition. Therefore, policy makers should take proper steps to increase the literacy rate as much as possible.

**Keywords:** Stunting, Multilevel Mixed-effects, under five children, Associated factors, Model Comparison, Bangladesh.

# Introduction

Stunting is one of the most well-established risk factor of poor child development. Globally, 149.2 million under five children (22.0%) are suffering from stunting in 2020 [1]. There is an international goal to reduce the number of stunted children from 171 million in 2010 to about 100 million in 2025, however at current rate it will most likely be 127 million stunted children by 2025 [2].

In Africa, 58.7 million children under the age of five are stunted. It is responsible for 39 percent of stunted children under the age of five across the world [3]. In 2017, Sub-Saharan Africa remained the region with the highest under-five mortality rate globally. One of the Sub-Saharan African countries are Ethiopia (the second-most populous country in Africa after Nigeria), this country has seen a persistent reduction in stunting among children from 58 percent in 2000 to 38 percent in 2016 [4]

Stunting has long-term impacts on individuals and societies [5]. The recent prevalence of stunting in Southern Asia is 30.7 percent, which is greater than the global norm of 22.0 percent, due to malnutrition [6]. If we look at the stunting percentage of India (a South Asian country) then it is quite moderate because there were 54% of children who were stunted [7]. Particularly, in Bangladesh, nearly 41% of children under five years old were stunted in 2017 and a higher proportion (42.54%) is detected in rural areas [3]. Bangladesh has undergone rapid urbanization in recent years, and it is predicted that there will be 50% more urban population by 2050 [8]. Bangladesh has also set an example of reducing child stunting in the last decade though it is very small. The prevalence is extremely concentrated on characteristics such as wealth index, exposure of the mother to the mass media, age of the child, size of child at birth, and parents' education in this area [9].

Child stunting is an outcome of long-term chronic intake of a low-quality diet (which leads to malnutrition) in combination with morbidity, contagious diseases, and environmental problems. Research shows that educated parents are better at taking care of their children than uneducated ones [10]. Consumption of food with insufficient calories and fewer than four different food groups consumed by children per day are key predictors of malnutrition [11].Past studies have shown that low maternal body mass index, low standard of living score, lower mental capacity, bad school

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performance, less productivity are the consequences of overall stunting. These are severely linked with poverty, female literacy, nuclear family, gross product, region of living [7,9,12]. Most often children with differential nutritional consumption, socioeconomic and cultural variation and differences in their genetic potential affect them to achieve maximum height [13].

Moreover, the fundamental causes of having stunting among under-five children are multifactored such as low income, less than two meals per day, being female sex, father's occupation, maternal and paternal education, polygamous family settings, exclusive breastfeeding, ethnic minority [11,12,14,15]. So, these factors initially set a barrier to the children from their childhood to grow properly in height and be productive in the future which also impedes the socio-economic development of a country. The factors which are actively maximizing the risk of stunting among school-going adolescents are gender discrimination, age, types of meals, mother's education, sources of drinking water, menstruation status, cold or cough, and diarrhea [5,11]. Therefore, reducing the risk of factors that are associated with stunting, limiting the number of pregnancies, prevention of diarrheal diseases has received sudden attention by the improvement partners and has been considered as future development goals in this field [3,9,16].

The research on the prevalence of stunting and its associated factors has been already covered by many country's contexts. These studies vary from each other based on methodology, data collection procedure, analysis, study sites, and participants. As far as, in our knowledge, it is the first study in Bangladesh that is conducted by using recent data from the Bangladesh Demographic and Health Survey (BDHS) 2017-18 to identify the prevalence of stunting and its associated risk factors.

Moreover, the BDHS 2017-18 sample was a stratified cluster and was chosen in two steps. Multilevel dependency or correlation among the observations is frequently introduced by this stratified cluster sampling strategy, which might have an impact on model parameter estimates. In that case, the multilevel statistical approach has additional benefits over the classical one. In the classical approach, the population parameter is assumed to be a fixed unknown constant whereas, in the Multilevel approach it is assumed to be a random variable that follows a certain probability distribution. Another advantage of the Multilevel approach is that in

current data it is possible to include prior information or experience and combine them to improve their prior knowledge for estimating parameters and construct inference [17].

The aim of our study is to identify the factors of stunting among under-five children with both the multilevel statistical approach and binary logistic regression approach and compare both study findings to determine the perfect model which gives presumably the best result. The reliance among observations in multistage clustered samples sometimes derives from multiple levels of the hierarchy. Single-level statistical models are no longer viable or appropriate in this circumstance. As a result, we may need to use techniques like multilevel modeling to derive suitable inferences and conclusions from multistage stratified clustered survey data. So, the outcome of this study will help the stakeholders, health-related policymakers, public health researchers to understand the current situation of stunting in Bangladesh, which may help take further actions and interventions to improve this condition [18].

## Methodology

*Data source and sampling technique:*

Secondary data analysis was conducted for this study and data was collected from the Bangladesh Demographic and Health Survey (BDHS) 2017-18. The BDHS report is publicly available and may be accessed upon request (The DHS Program - Available Datasets).

The 2017-18 BDHS sample is nationally representative, covering the whole population of non-institutional housing units across the country. As a sample frame, the Bangladesh Bureau of Statistics (BBS) supplied a list of enumeration areas (EAs) from the 2011 People's Republic of Bangladesh Population and Housing Census (BBS 2011). About 120 households were surveyed on average in an EA as the primary sampling unit (PSU).

A two-stage stratified sample of households was conducted in this survey. In the first stage, 675 EAs were chosen with a probability proportional to EA size (250 in urban regions and 425 in rural areas). To provide a sampling frame for the second-stage selection of households, a comprehensive household listing operation was carried out in all selected EAs. On average, 30 households per EA were chosen in a systematic sample to produce statistically credible estimates of key demographic and health indicators for the nation, for urban and rural regions individually,

and for each of the eight administrative divisions in the second stage. Initially, 20,250 residential households were selected and expected to interview about 20,100 ever-married women aged 15-49. At last, 20,160 households were selected for the survey in total, the survey was successfully carried out in 672 clusters, after eliminating three clusters (one urban and two rural).

*Study variables and measurements*

Outcome variable: The status of child stunting is our outcome variable. We classified children under the age of five as stunted if their height-for-age Z-score was less than -2 SD from the WHO child growth reference, and as not stunted if their height-for-age Z-score was greater than -2 SD. In this study, our response variable is a dichotomous variable where category 0 if not stunted and category 1 for the stunted child. Independent variables: In accordance with the study's goals and because of the BDHS data's hierarchical structure, two-level independent variables were considered. They are individual level or first level variables and regional level or second level variables. We classified individual levels of independent variables in different groups such as socio-economic, demographic factors, and child-related factors. The socio-economic and demographic factors contain mother age (15-19, 20-24,25+), father age ($\geq$24, 25-29,30-34,35+), parents' educational level (no education, primary, secondary, or higher), father's occupation (Jobless, Farmer, Agriculture, Business, others), mother's work status (yes, no), wealth index (poor, middle, rich), religion (Islam, others), mothers' exposure to the mass media(yes, no), antenatal care ($\geq$4, <4), type of toilet facility (modern toilet. others), place of delivery (Home, hf), no. of household members ($\geq$3, <3), household head's sex (male, female). Child-related factors contain the age of the child (0-11, 12-23, 24-35, 36-47, and 48-59 months), the child's sex (Male, Female), a recent history of diarrhea (yes, no), a recent history of cough (yes, no), a recent history of fever (yes, no), c-section (yes, no), birth order (1-3,4-6,7-10). On the other hand, division and area of residence (urban, rural) are regional levels or secondary level independent variables. Detailed information of these variables can be found in **Table-1**.

*Data management and analysis*

This dataset was cleaned, recoded, and analyzed according to the DHS guide 7 using Stata version 14.0 and weighted using sampling weight. To adjust the complex survey design primary sampling unit, and strata are considered before any statistical analyses were done to restore the representativeness of the survey. To perform a survey representative multilevel

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mixed-effects logistic regression model in Stata we need to follow a methodological report of DHS [19]. We used the Svyset command in Stata (StataCorp LP, College Station, Texas) by considering the complex survey design.

Firstly, we conducted a bivariate exploratory data analysis (EDA) to reveal the distribution of sampled respondents with child stunting and reported the outcome in frequency along with individual row percentage. The bivariate analysis was performed to understand the situation of child stunting among the individual level and regional level independent variables. After EDA, we performed a univariate binary logistic regression model (as our outcome variable is dichotomous) in which each variable at the individual and regional level as an independent variable. After that, to identify the risk factors of child stunting in single level, we carried out a multivariable binary logistic regression model.

The univariate logistic regression model can be expressed as,

$$\left[\frac{\pi(X_i)}{1 - \pi(X_i)}\right] = \beta_0 + \beta_1 X_i$$

where the quantity $\pi(X) = E(y_i|X)$ represent the conditional probability that Y=1 (stunted) given X and expressed as,

$$\pi(X_i) = \frac{e^{\beta_0 + \beta_1 X_i}}{1 + e^{\beta_0 + \beta_1 X_i}};$$

If one considers a collection of p independent variables denoted by the vector $X_i = (X1, X2, …, Xp)$ then the multivariable logistic regression model is given by the equation as

$$\left[\frac{\pi(X_i)}{1 - \pi(X_i)}\right] = \beta_0 + \beta_1 X_{1_i} + \beta_2 X_{2i} + - - - - - + \beta_p X_{pi}$$

Before conducting the multilevel model, we calculated the intra-class correlation coefficient (ICC) by using the formula,

$$ICC = \frac{var(U_{0j})}{var(U_{0j}) + \left(\frac{\pi^2}{3}\right)}$$

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where $var(U_{0j})$ is the random intercept variance, i.e., the level-2 variance. The value of ICC ranges from 0 to 1. Only when the ICC is greater than 0 then a multilevel logistic regression model is applicable [20].

Finally, we performed a multilevel mixed-effects logistic regression model using the exact same independent and dependent variable we used in the previous model. The equation of the multilevel model can be written as,

$$logit\,(\pi_{ij}) = \beta_0 + \beta_k X_{ij} + u_j$$

where i and j refers the level-1 and level 2 respectively and $u_j \sim N(0, \sigma2)$.

To measure the strength of the association between "stunting" and determinant factors we used adjusted odds ratios (AORs) with 95% confidence intervals (CIs) and associations with p-value $< 0.05$ defined as a significant association for both models. As our main goal was to identify best fitted models we performed several goodness of fit tests e.g., Akaike information criterion (AIC), the Bayesian information criterion (BIC), Log-likelihood. AIC and BIC are calculated as, AIC $= -2$ (log-likelihood of the fitted model) $+2p$, and BIC $= 2$ (log-likelihood of the fitted model) $+ \ln(N)*p$. where p is the degree of freedom in the model and N is the number of observations in the sample. After comparing the AIC and BIC values for each model, the lowest one was deemed to be the better explanatory model (de Jong & Heller, 2008). The Area under the Receiver Operating Characteristic (AUROC) is also constructed which is the indicator of sensitivity and specificity. Lower P-values in the ROC curve indicate that the model can differentiate between two groups, and the area under the curve is greater than 0.50 [21].

## Results

In this study, a total of 7902 child mothers participated and gave their information. Among them 30.48% children were stunted. After the analysis, it is evident that most of the stunted children (38.54%) were found in poor family settings in Bangladesh. About 30% of these families have more than three family members and 46% of children with birth order 7-10 are most likely to suffer from stunting. In comparison to urban areas (25%), the prevalence of stunting in children under the age of five was higher in rural areas (32%). Division–wise

distribution of prevalence presents that Mymensingh was a high-risk area for stunting, where the prevalence was about 42%, and Dhaka and Khulna divisions were the low-risk areas for stunting.

However, the greatest number of stunted children was found in the families where household heads are fathers (30%) who are involved in an agricultural occupation (40%). No proper education also evokes this problem significantly. As 43% of household heads have no academic education which leads to their unhealthy lifestyle.

Moreover, female education is one of the essential factors because mothers with higher education have a huge contribution to reducing the prevalence of stunting to15%. While we can see with no education 42% of mothers increase the possibility of stunting. But in some households, the prevalence of stunting is high (33%) because of working mothers. In Bangladesh, 32% of females with the age range 15-19 have children with stunting problems.

In general, the prevalence of stunting rises with the age of the child but mostly it is noticeable within the children (38%) who are between (24-35) months age range. However, children whose mothers got antenatal care (more than 4 times) before delivery had a considerably decreased rate of stunting (25%) compared to those (33%) who didn't. At the same time mothers who didn't go through cesarean delivery (34%) increase the possibility of having stunting in their children. The stunting rate among children is high whose mother's place of delivery is home (35%) rather than the hospital (24%). We found that stunting prevalence is higher among children whose mothers had no access to those mass media. In Bangladesh, most of the households don't have improved toilet facilities (32%). In the two weeks leading up to the survey, about 30% percent of stunned children had diarrheal episodes, fever, and cough in particular. (**Table 1**)

Both models, multivariable logistic regression and multilevel logistic regression refer to a degree of association between Stunting Status and socio-demographic profiles of children. . In both analyses, there are significant variations that explain which model will be most preferable for this study.

However, the odds ratio of division from the multivariable logistic regression model shows that Mymensingh had 1.65 times (OR: 1.658, 95% CI: 1.29 - 2.12) chance of being stunted than Dhaka whereas in the multilevel model it shows 2 times (OR: 2.01, 95% CI: 1.47 - 2.75) greater chance than that which is more reliable. The multilevel model also gives a clear result about the division that Chittagong (OR: 1.41, 95% CI: 1.00-1.98) had a higher chance of being stunted than Dhaka. According to the mother's education level, all categories such as no education, primary and secondary are significantly correlated with children stunting in both models. But the noticeable matter in the multivariable and multilevel model is mothers with no education had a 2.00 times higher chance (OR:2.00, 95% CI:1.44 - 2.77) and 2.06 times (OR: 2.06, 95% CI: 1.41 - 3.02) higher chance of having stunted children than the women with higher education.

However, household head's education level result shows all the categories are significantly associated with stunting. From the outcome of the multivariable model household head with no education had 98% (OR: 1.98, 95% CI:1.52 - 2.59), the primary had 67% (OR: 1.67, 95% CI:1.33 - 2.11) and secondary had 39% (OR: 1.39, 95% CI:1.12 - 1.73) higher chance of having stunted child. On the other side multilevel model gives a more relevant result that, household head with no education had 2 times (OR: 2.00, 95% CI:1.41-3.02), primary had 99% (OR: 1.99, 95% CI:1.49 - 2.66) and secondary had 70% (OR: 1.70, 95% CI: 1.32-2.20) higher chance of having stunted children than the higher educated one. By comparing both models, it is evident that household heads with agricultural occupation had 28% (OR: 1.70, 95% CI: 1.32-2.20) higher chance in the multivariable model and 39% (OR: 1.70, 95% CI: 1.32-2.20) higher chance of stunting in a multilevel model.

Moreover, in the multivariable model we see that poor family settings had a 35% (OR: 1.35, 95% CI: 1.11-1.64) higher chance while the multilevel model shows poor family settings had 51% (OR: 1.50, 95% CI: 1.20-1.89) higher chance than rich families. Based on child age, when all other variables are adjusted, the most vulnerable age group (24-35) months children had 2.63 times (OR: 2.63, 95% CI: 2.16-3.19) higher chance and 3.03 times (OR: 3.03, 95% CI: 2.42- 3.80) higher chance of stunting in a multivariable and multilevel model. So overall the analysis demonstrates that the multilevel logistic regression model describes the obvious and clear result of the data. (**Table 2**).

In this analysis, the values of AIC, BIC for multivariable and Multilevel models are 8997.297,9198.979 and 8985.347, 9193.984 respectively. The lower value of AIC, BIC, and Log-likelihood indicates a better fit model. From both models, we found that the Multilevel regression model has the lowest value of AIC, BIC, and Log-likelihood (8997.297,9198.979, -4469.649) than the Multivariable model. This also implies that the addition of the regional characteristics enhanced the multilevel model's capacity to explain differences in childhood stunting between regions. Our model fitting criteria the AUC of receiver operating characteristic curve (ROC) was identified to be 0.6793(Asymptotic p-value: <0.001 and 95% CI: 0.66 - 0.69) and 0.7117(Asymptotic p-value: <0.001and 95% CI: 0.69 - 0.72) for our final Multivariable and Multilevel models showed higher area under curve than 0.50. Basically, a receiver operating characteristic curve (ROC curve) is a graph that shows how well a classification model performs across all classification thresholds. Generally, an AUC of 0.5 indicates that there is no discrimination, and greater than this is considered as acceptable or excellent. In our study, the value of AUC is greater in the Multilevel regression model that is 0.7117. So, without any doubt the Multilevel model is the better-fitted model for this study **(Table 3)**.

## Discussion

In this study, the prevalence of stunting of under five years old children was found to be 30.48% in Bangladesh. At the individual level mother's education, father's education, household head occupation, wealth index, and age of the child were found as significant factors. On the other hand, the only division was a significant factor at the regional level. This study examined the comparison between multivariate logistic regression and multilevel mixed-effects logistic regression models while estimating or predicting the significant risk factors of child stunting.

In the present study, child stunting was found to increase as the mother's education level decreased in both models. Similar results were found in other studies of Bangladesh, some developing countries, and Nigeria's study [3,22,23]. But the odds ratio of the multilevel mixed-effects model is higher in each category than the multivariate model. The reason behind this result could be that educated mothers are more concerned about child nutrition and it also shows us the importance of female education to reduce malnutrition.  For the father's education level, the study found evidence of similar consequences like the mother's education level. A study of different regions of Ethiopia also shows father education level is inversely correlated with child

stunting [24-26]. So, this study revealed that education is a vital factor to ensure proper childcare in the country.

Household head occupation also plays an important role in child stunting. The study found that household heads with agricultural backgrounds who are farmers or do other agricultural-related works were more vulnerable for child stunted growth than household heads with occupation business. But there was a slight difference in results between the two models. Households who were farmers were found to be a significant factor in the multivariate logistic regression model but not in the multilevel mixed-effects logistic regression model. So, it represents that farmers' categories are apparently not associated with stunting problems among children when we seek the genuine result. Mothers with agricultural occupations were also found as a risk factor for child stunting in studies of India and China [27,28]. Fathers and mothers with agricultural occupations need to stay the whole day in the field as a reason they could not take care of their children as much as a businessperson can.

As a consequence of the household head occupation, this study also identified that household wealth is also associated with child stunting. Children from poor and middle-class households are more likely to be stunted than children from rich families. A similar insight was found in studies of a different regions of Ethiopia, Nepal, India (West Bengal), Nigeria, Rwanda, Indonesia [5,7,13,14,22,29-32]. Hence, we can easily see that child stunting in poor families is a worldwide problem. They hardly even manage their three meals in a day. So, it is difficult for poor families to afford household food, sanitation, and health care, all of which are key contributors to child stunting.

This study revealed that children in 24-35 months age groups are more at risk of child stunting though children of all age groups were found to be significantly associated with stunted growth. There could be many reasons behind this output. Most importantly at two years old infants start to eat other food properly than breast milk. At that time children need other nutritional food to grow up properly. This could be a reason that lack of healthy and nutritious food affects the regular growth of children. A similar age group was found vulnerable in studies of Ethiopia, Rwanda, Eswatini, and in a study of Bangladesh using BDHS 2014 data [15,31,33,34]. There are many other studies where different age groups found to be more vulnerable to child stunting[22,24,25,28,35,36,37]

At the regional level, the study evident that division was a significantly associated factor with child stunting. Among 8 administrative divisions, the Mymensingh division was found to be significant in the multivariate logistic regression model, but Chattogram division was also found to be significantly associated with child stunting in the multilevel logistic regression model. Mymensingh is the newly added division in Bangladesh. It could be a reason that the health and other facilities that other divisions got for a long period of time Mymensingh did not get till yet. Furthermore, low literacy, poverty, and factors could be a reason behind this. Mymensingh division found the most vulnerable division for child stunting in another study of Bangladesh [38]

**Conclusion**

Child stunting remains a developing topic in Bangladesh, about 39% of children under five years old are still being stunted. This study reveals that educated parents are playing a vital role in reducing child malnutrition. So, policy makers should take proper steps to increase the literacy rate as much as possible which would help the country in the long run. This study also identified that 24-35 months aged children are in more danger than others. Government and non-government organizations should arrange some programs to provide nutrient-dense foods to 24-35 months aged children. Moreover, it is necessary to minimize disparities, there is a clear need to eliminate economic inequalities and, eventually, poverty among households. In addition, the government should pay special emphasis to improving the nutrition condition of under-five children in areas with a high prevalence of child stunting particularly in Mymensingh division.

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