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

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**Abstract**

**Objective/ Research Question:** 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.

**Design:** We used nationally representative data from the Bangladesh Demographic and Health Survey (BDHS) 2017-18.

**Setting:** Bangladesh.

**Participants:** 7881 children aged under-five years.

**Primary outcome:** Child Stunting.

**Result:** About 30.78% of children were found to be stunted in Bangladesh. We found children from poor families are stunted in higher percentages (38.54%) when compared to those from higher wealth, and also the rate was higher in rural areas (32%). The most vulnerable age group 24-35 months children had found to have a 3.22 times (OR: 3.22, 95% CI: 2.51-4.14) higher chance of stunting. The study also revealed that cesarean delivery had a 30% (OR: 1.3, 95% CI: 1.03-1.63) and children whose mothers did not take iron tablets during their pregnancy had a 35% (OR: 1.35, 95% CI: 1.06-1.71) greater risk to have stunted children at a later age. Furthermore, division, fathers’ and mothers’ education level, and wealth index were significantly associated with stunting.

**Conclusion:** The prevalence of stunting is still high in Bangladesh. Most importantly, we have to take extra care of 24-35 months children and children from Chattogram, Mymensingh, and Sylhet divisions. Also, the government should ensure providing iron tablets during pregnancy to mothers and discourage C-section delivery as long as the situation is normal. Therefore, policymakers should take proper steps to provide special care for children and mothers of mentioned groups and areas.

**Keywords:**  Stunting, Multilevel Mixed-effects, under-five children, associated factors, Bangladesh.

**Strengths and limitations of this study**

The study’s main limitation is that the BDHS 2017-18 is cross-sectional data. Longitudinal research would have been conducted to profile study participants across time. Furthermore, we cannot incorporate various possible risk factors such as the size of the baby at birth, daily meals, hygiene practices-related data, mothers’ pre-pregnancy data, etc. due to the unavailability of data and missing data. Despite these constraints, methodologically it was a very strong study; there are very few studies using this type of modeling.

## Introduction

One of the most widely known risks for poor child development is stunting. Globally, 149.2 million under-five children (22.0%) were suffering from stunting in 2020 1. 58.7 million African children under the age of five are stunted. Worldwide, it is to responsible for 39% of children under five who are stunted 2. Furthermore, recent Southern Asia is 30.7 percent, which is greater than the global norm of 22.0 percent3. In Bangladesh, nearly 41% of children under five years old were stunted in 2011, and a higher proportion of stunted children (42.54%) were detected in rural areas 4. Globally, it is desired to reduce the number of stunted children under five from 171 million in 2010 to around 100 million in 2025. But if things continue as they are, by 2025 there will certainly be 127 million stunted children 5. The prevalence of stunting is highly associated with 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 6. Other studies besides those conducted in Bangladesh demonstrate that educated parents’ children are less stunted than those without education 4. Also, 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 problems7. Consumption of food with insufficient calories and fewer than four food groups consumed by children per day are key predictors of malnutrition 8. Past studies in Southwest Nigeria have shown that low maternal body mass index, low standard of living score, lower mental capacity, differential nutritional consumption, socioeconomic and cultural variation, differences in genetic potential, and less productivity are the consequences of overall stunting. These are severely linked with poverty, female literacy, nuclear family, gross product, and region of living 6,9,10.

Moreover, the fundamental causes of 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, and exclusive breastfeeding, ethnic minority 8,9,11–15. So, these factors initially set a barrier for 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 actively maximizing the risk of stunting among school-going adolescents are gender discrimination, age, types of meals, mother's education, drinking water sources, menstruation status, cold or cough, and diarrhea 8,16. Therefore, reducing the risk of factors associated with stunting, limiting the number of pregnancies, and preventing diarrheal diseases have received sudden attention from the improvement partners and have been considered future development goals in this field 4,6,17.

The study on the prevalence of stunting and its associated factors has been already covered by many countries' contexts. These studies vary based on methodology, data collection procedure, analysis, study sites, and participants. As far as our knowledge, it is the first study in Bangladesh conducted using a multilevel logistic regression approach on the last updated data from the Bangladesh Demographic and Health Survey (BDHS) 2017-18 to identify risk factors associated with childhood stunting.

Furthermore, the BDHS 2017-18 sample was a stratified cluster and was chosen in two steps. Correlation among the observations is frequently introduced by this stratified cluster sampling strategy, which might impact multilevel binary model parameter estimates. In that case, the multilevel statistical approach has additional benefits over the classical one. The dependency among observations in multistage clustered samples derives from multiple levels of the hierarchy. Single-level statistical models are no longer appropriate in this circumstance. As a result, we may need to use techniques like multilevel modeling to derive suitable inferences. According to some previous research, we found that they have data that has the same structure as BDHS but didn’t consider the multilevel modeling approach4,16,18,19. Also, we found some studies that had used multi-level modeling in previous datasets of BDHS 20,21.

Our study aims to find the factors of stunting among under-five children using the multilevel logistic regression model on the recent dataset. So, the outcome of this study will help the stakeholders, health-related policymakers, and public health researchers to understand the current situation of stunting in Bangladesh, which may help take further actions and interventions to improve this condition 22.

**Methods**

*Data source and sampling technique:*

This study relied on secondary data, which was gathered from the Bangladesh Demographic and Health Survey (BDHS) 2017-18. The BDHS data is available for all and can be accessed upon request ([The DHS Program - Available Datasets](https://dhsprogram.com/data/available-datasets.cfm)).

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 record of enumeration areas (EAs) from the 2011 People's Republic of Bangladesh Population and Housing Census (BBS 2011). On average, about 120 households were surveyed 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 and 425 in rural areas). To produce 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 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).

**Patient and Public Involvement**

The BDHS questionnaires were based on the MEASURE DHS model questionnaires. These sample questions were modified for use in Bangladesh during a series of meetings with a technical working group (TWG) made up of representatives from NIPORT, Mitra and Associates, the International Centre for Diarrheal Diseases and Control, Bangladesh (icddr, b), USAID/Bangladesh, and MEASURE DHS. Patients were not directly involved in the study; however, the TWG was involved in the research design and questionnaire creation, as were representatives from the government, non-government groups, the ministry of health and family welfare, and donor organizations. The nation's health experts and policymakers will make use of the findings.

*Study variables and measurements*

Outcome variable: The status of child stunting is our outcome variable. We classified children under the age of five as not 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 23. In this study, our response variable is a dichotomous variable where category 0 of not stunted, and category 1 is for the stunted child.

Independent variables:  By 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 are mother age (15-19, 20-24,25+), father age (≥24, 25-29,30-34,35+), mothers’ and their partners’ educational level (no education, primary, secondary, or higher), household heads’ 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), the number of antenatal care visits made by the respondent (≥4, <4), whether taken any prenatal care service (yes, no), method of delivery (normal, caesarean), whether there exists any delivery assistance (yes, no), consuming iron tablet during pregnancy (yes, no), type of toilet facility (modern toilet. others), place of delivery (home, health facility), no. of household members (≥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), birth order (1-3,4-6,7-10). On the other hand, division, and area of residence (urban, rural) are regional or secondary-level independent variables. Detailed information on these variables can be found in **Table 1 to Table 4**.

*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, the primary sampling unit, and strata were considered before any statistical analyses were done to restore the representativeness of the survey. To perform a survey representative multilevel mixed-effects logistic regression model in Stata we need to follow a methodological report of DHS 24. We used the Svyset command in Stata (StataCorp LP, College Station, Texas) by considering the complex survey design. Additionally, we followed the STROBE cross-sectional reporting guidelines 25.

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 at a single level, we carried out a multivariable binary logistic regression model.

The univariate logistic regression model can be expressed as,

where the quantity represents the conditional probability that Y=1 (stunted) given X and expressed as,

;

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

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

where 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 26.

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

*logit () =*

where i and j refer the level-1 and level 2 respectively and 𝑢𝑗 ~ 𝑁(0, 𝜎2).

To evaluate the strength of the association between “stunting” and determinant factors we used odds ratios (ORs) with 95% confidence intervals (CIs) and associations with a p-value < 0.05 defined as a significant association for both models. As our main goal was to identify the best-fitted models, we performed several goodness of fit tests, e.g., Akaike information criterion (AIC), the Bayesian information criterion (BIC), and Log-likelihood. After comparing each model’s AIC and BIC values, the lowest one was deemed the better explanatory model27. The Area under the Receiver Operating Characteristic (AUROC) is also constructed as 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 28.

# **Results**

A total of 7902 child mothers participated and gave their information on 7881 children. Among them, 30.78% of children were stunted. In Bangladesh, 38.54% of poor families’ children are stunted which was more than middle (29.8%) and rich (21.92%) families. About 30% of children with more than three family members were stunted, and 46% of children with birth orders 7-10 were 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%). Geographic location (division)–wise distribution of prevalence presents that Sylhet 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 (Figure 1).

However, the highest percentage (40%) of children were stunted in families where the household head’s profession is agriculture. The study showed that fathers with no academic education had a 43% stunting rate in their children, and with primary education, the rate was 35.55%. Moreover, mothers with higher education greatly contributed to reducing the prevalence of stunting. As we can see with no education, 42% of the children with uneducated mothers were stunted. But in some households, the prevalence of stunting is high (33%) because of working mothers. In Bangladesh, 32% of females in the age range 15-19 had children with stunting problems.

In general, the prevalence of stunting was raised with the age of the child, but mostly it was noticeable in children (38%) who were between (24-35) months of age range. However, children whose mothers got antenatal care (more than four 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 stunting in their children. The stunting rate among children was high whose mother's place of delivery was home (35%) rather than the hospital (24%). We found that stunting prevalence is higher (34.73%) among children whose mothers had no access to the mass media. (**Table 1, Table 2, Table 3, Table 4**).

Both models, multivariable and multilevel logistic regression, refer to a degree of association between stunting status and socio-demographic profiles of children. In both analyses, significant variations explain which model will be most preferable for this study. The odds ratio of division from the multilevel logistic regression model showed that children from Sylhet had 2 times (OR: 2.2, 95% CI: 1.43-3.38) greater chance of being stunted than children from Dhaka. We observed that children from another division, Mymensingh, had an 86% (OR: 1.86, 95% CI: 1.15-3.01) chance of being stunted.  It also gave a clear result about the children from the Chittagong division, which had a 65% (OR: 1.65, 95% CI: 1.04-2.62) higher chance of being stunted than children from Dhaka. According to the mother's education level, the odds/chance of stunting was significantly higher among children of mothers with primary/secondary education in comparison to children of mothers with a higher level of education. The noticeable matter was that mothers with primary education had an 86% (OR:1.86, 95% CI: 1.25-2.75) higher chance of having stunted children than women with higher education. Similarly, fathers with no education had 2.19 times (OR: 2.19, 95% CI: 1.43-3.33) a higher chance of having stunted children than fathers with higher education.

Although we observed that poor family settings had a 50% (OR: 1.50, 95% CI: 1.11-2.05) and middle-class families had a 35% (OR: 1.35, 95% CI: 1.01-1.81) higher chance of having stunted children than rich families. We also found that mothers who experienced caesarean delivery had a 30% (OR: 1.3, 95% CI: 1.03-1.63) greater chance of having stunted children than the mother who went through normal delivery. Mothers who did not take iron tablets during their pregnancy had a 35% (OR: 1.35, 95% CI: 1.06-1.71) chance to have stunted children.  Based on child age, when all other variables were adjusted, the most vulnerable age group (24-35) months children had 3.22 times (OR: 3.22, 95% CI: 2.51-4.14) higher chance of stunting than 0-11 months children. However, all the children's age groups were significantly associated with stunting than the (0-11) months age group in the Multilevel model. (**Table 5**).

  In this analysis, the values of AIC and BIC for Multivariable and Multilevel models were 5297.601, 5508.413, and 5296.675, 5503.919, respectively. The lower AIC, BIC, and higher Log-likelihood values indicate a better fit model. From both models, we found that the Multilevel regression model had a lower value of AIC, BIC, and a higher value of Log-likelihood (5296.675, 5503.919, -2616.8) than the Multivariable model. This also implies that adding 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 0.6839 (Asymptotic p-value: <0.001 and 95% CI: 0.67-0.70) and 0.7072 (Asymptotic p-value: <0.001 and 95% CI: 0.69 - 0.72)) for our final Multivariable and Multilevel models showed a higher area under the curve than 0.50. A Receiver Operating Characteristic curve (ROC curve) is a graph that presents how well a classification model executes across all classification thresholds. Generally, an AUC of 0.5 indicates no discrimination, and greater than this is considered acceptable or excellent. In our study, the value of AUC was greater in the Multilevel regression model, which is 0.7072. So, without any doubt, the Multilevel model is the better-fitted model for this study **(Table 6)**.

# **Discussion**

In this study, the prevalence of stunting of under five years old children was found to be 30.78% in Bangladesh. At the individual level, the mother’s education, father’s education, methods of child delivery, iron tablet during the mother’s pregnancy, wealth index, and age of the child were significantly associated with stunting. On the other hand, the only division was a significant factor at the regional level.

In the present study, child stunting was found to increase as the mother’s education level decreased. Similar results were found in other studies of Bangladesh, some developing countries, and Nigeria's study 4,29,30. 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 in reducing malnutrition.  For the father’s education level, the study found evidence of similar consequences to the mother’s education level. A study of different regions of Ethiopia also shows father’s education level is inversely correlated with child stunting 19,31,32. So, this study revealed that education is vital to ensure proper childcare in the country.

This study revealed great insight into the impact of C-section delivery on child stunting. Mothers who had experienced caesarean delivery of their children are more exposed to being stunted. Few studies in Ghana and India also evidenced that C-section delivery is a significant risk factor for child stunting 33,34. Nowadays hospitals and health facilities centers are forced to perform caesarean delivery to earn some extra money 35. So, everyone should discourage c-section delivery for reducing child stunting and other children nutritional lacking until the situation is under control.

Another engrossing result unfolded by this current study is that iron tablet consumption by mothers during pregnancy reduces child stunting. Several studies by many researchers also identified regular intake of iron tablets during the pregnancy period decreases the chance of being stunted in a child 36–39. So, every mother should ensure taking iron tablets or syrup adequately and responsibly during pregnancy.

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 different regions of Ethiopia, Nepal, India (West Bengal), Nigeria, Rwanda, and Indonesia 10,11,16,29,40–44. Hence, we can easily see that child stunting in poor families is a global 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, which are key contributors to child stunting.

This study revealed that children in the 24-35 months age group 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, infants start to eat other food properly than breast milk at two years old. 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 normal growth of children. A similar age group was found vulnerable in studies of Ethiopia, Rwanda, Eswatini, and a study in Bangladesh using BDHS 2014 data 12,42,45,46. Many other studies showed that different age groups were more vulnerable to child stunting.29,31,32,47–50

At the regional level, the study evident that division was a significantly associated factor with child stunting. Among eight administrative divisions, Chattogram, Mymensingh, and Sylhet division was significantly associated with child stunting in the multilevel logistic regression model. Sylhet is situated in the northeastern part of Bangladesh, the most flood-affected area and Chattogram is a coastal area where frequent waterlogging happens. It could be a reason why malnutrition, as well as child stunting, is severe in this division 51. Furthermore, low literacy, poverty, and other factors could be the reasons behind this. Sylhet division was found to be the most vulnerable division for child stunting in another study of Bangladesh.4,21,45.

# **Conclusion**

Child stunting remains a developing topic in Bangladesh; about 31% of children under five are still being stunted. This study revealed that educated parents play a vital role in reducing child malnutrition. So, policymakers should take proper steps to increase the literacy rate as much as possible, which would help the country in the long run. Most importantly, in the present investigation, we demonstrated Iron tablet consumption during pregnancy and the vaginal delivery method of childbirth was found to be significantly associated with child stunting. So, Government and non-government organizations (NGOs) should take this outcome seriously and organize some events to increase awareness of iron tablet consumption during the pregnancy period, and also encourage avoidance of C-section delivery if possible or until the situation remains under control. It will be more appreciable if the government could provide free iron tablets for pregnant mothers in govt. hospitals and clinics. This study also identified that 24-35 months aged children are in more danger than other age-groups. Government and NGOs should arrange some special programs to provide nutrient-dense foods to 24-35 months aged children besides other children of other ages. 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 emphasize improving the nutrition condition of under-five children in areas with a high prevalence of child stunting, particularly in the Sylhet division.

# **List of abbreviations**

AIC Akaike Information Criterion

AUC Area Under Curve

BDHS Bangladesh Demographic and Health Survey

BIC Bayesian Information Criterion

EAs Enumeration Areas

EDA Exploratory Data Analysis

ICC Intra-class Correlation Coefficient

NGOs Non-Government Organizations

OR Odds Ratio

ROC Receiver Operating Characteristic

SD Standard Deviation

WHO World Health Organization

**Declarations**

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**Author Contributions:**

ANM, STAN, MNH, and MJU conceptualized the study, designed the analytic approach, managed, and performed the analysis, interpreted the results, and drafted the manuscript. MJU and MABC helped with the analysis, reviewed, edited, and updated the manuscript. Finally, all authors read and approved the final manuscript.

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**Availability of data and material:** Data are available on request from the DHS program website (<https://dhsprogram.com/data/dataset/Bangladesh_Standard-DHS_2017.cfm>)

**Ethics approval and consent to participate:** The ethics application has been approved by the Biostatistics research group, Department of Statistics, Shahjalal University of Science and Technology, Sylhet-3114, Bangladesh (no. sta/2022/6/toukir/04). The study has been conducted using publicly available survey data with all identifier information removed. Details of ethics approval for DHS is available at: <https://dhsprogram.com/Methodology/Protecting-the-Privacy-of-DHS-Survey-Respondents.cfm>. The survey was approved by the Ethics Committee of the ICF International at Rockville, Maryland, USA, and by the Ethics Committee of the Ministry of Health and Family Welfare. The study is conducted by the principles of the Declaration of Helsinki. All BDHS participants provided written informed consent before participation and all information was collected confidentially.

**Consent for publication:** Not applicable

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**Table and figures**

**Table 1: Distribution of child stunting in socio-economic and demographic characteristics**

|  |  |  |
| --- | --- | --- |
| **Variables** | **Child Stunting** | |
| **Not Stunted**  **N (%)** | **Stunted**  **N (%)** |
| **Mother Age** |  |  |
| 15-19 | 696.9  (67.90) | 329.5  (32.10) |
| 20-24 | 1914  (70.05) | 818.3  (29.95) |
| 25+ | 2869  (69.59) | 1254  (30.41) |
| **Mothers’ Education** |  |  |
| No education | 325.3  (57.57) | 239.7  (42.43) |
| Primary | 1392  (61.57) | 868.7  (38.43) |
| Secondary | 2734  (71.10) | 1111  (28.90) |
| Higher secondary or above | 1028  (84.97) | 181.8  (15.03) |
| **Fathers’ Education** |  |  |
| No education | 657.6 (56.92) | 497.7 (43.08) |
| Primary | 1729 (64.45) | 953.8 (35.55) |
| Secondary | 1877 (73.13) | 689.6 (26.87) |
| Higher secondary or above | 1122 (84.05) | 213 (15.95) |
| **Fathers’ Age** |  |  |
| >=24 | 293.3  (66.74) | 146.1  (33.26) |
| 25-29 | 1172  (68.12) | 548.3  (31.88) |
| 30-34 | 1412  (70.86) | 580.7  (29.14) |
| 35+ | 2520  (69.92) | 1084  (30.08) |
| **Mothers’ Work Status** |  |  |
| No | 3373  (71.85) | 1322  (28.15) |
| Yes | 2106  (66.11) | 1080  (33.89) |
| **Household Heads’ Occupation** |  |  |
| Jobless | 38.97  (69.55) | 17.06  (30.45) |
| Farmer | 544.6  (64.45) | 300.40  (35.55) |
| Agriculture | 350.3  (59.24) | 241  (40.76) |
| Business | 1218  (74.50) | 416.80  (25.50) |
| Others | 3243  (70.15) | 1381  (29.86) |
| **Religion** |  |  |
| Islam | 5016  (69.37) | 2215  (30.63) |
| Others | 463.3  (71.31) | 186.4  (28.69) |
| **Wealth Index** |  |  |
| Poor | 2046  (61.46) | 1283  (38.54) |
| Middle | 1061  (70.2) | 450.5  (29.8) |
| Rich | 2372  (78.02) | 668.2  (21.92) |
| **No. of Household Members** |  |  |
| >=3 | 684  (70.78) | 282.4  (29.22) |
| 3> | 4795  (69.35) | 2119  (30.65) |
| **Household Heads’ Sex** |  |  |
| Male | 4732  (69.36) | 2091  (30.64) |
| Female | 747.2  (70.63) | 310.8  (29.37) |
| **Toilet facility** |  |  |
| Modern | 1539  (76.76) | 466  (23.24) |
| Others | 3940  (67.06) | 1935  (32.94) |
| **Partners Schooling type** |  |  |
| School | 4503  (71.98) | 1753  (28.02) |
| Madrasha | 243.1  (68.88) | 109.8  (31.12) |

**Table 2: Distribution of child stunting in pregnancy related characteristics**

|  |  |  |
| --- | --- | --- |
| **No. of Antenatal Care** |  |  |
| >=4 | 1633  (66.18) | 834.5  (33.82) |
| 4> | 1653  (74.37) | 569.7  (25.63) |
| **Mass Media facility** |  |  |
| No | 2969  (65.27) | 1580  (34.73) |
| Yes | 2510  (75.34) | 821.5  (24.66) |
| **Cesarean Section** |  |  |
| No | 2132  (65.4) | 1128  (34.6) |
| Yes | 1265  (77.93) | 358.4  (22.07) |
| **Prenatal Care** |  |  |
| No | 217.7  (58.38) | 155.2  (41.62) |
| Yes | 3069  (71.07) | 1249  (28.93) |
| **Delivery assistance** |  |  |
| No | 5.03  (92.90) | .38  (7.10) |
| Yes | 3397  (69.55) | 1487  (30.45) |
| **Iron tablet during pregnancy** |  |  |
| No | 2586  (70.1) | 995.5  (27.80) |
| Yes | 697.10  (63.30) | 404.10  (36.70) |

**Table 3: Distribution of child stunting in child-related characteristics**

|  |  |  |
| --- | --- | --- |
| **Variables** | **Child Stunting** | |
| **Not Stunted**  **N (%)** | **Stunted**  **N (%)** |
| **Child Stunting** | 5455  (69.22) | 2426  (30.78) |
| **Children’s sex** |  |  |
| Male | 2867  (69.55) | 1255  (30.45) |
| Female | 2612  (69.51) | 1146  (30.49) |
| **Children Age** |  |  |
| 0-11 | 1375  (80.25) | 338.3  (19.75) |
| 12-23 | 1082  (66.14) | 553.9  (33.86) |
| 24-35 | 944  (61.36) | 594.6  (38.64) |
| 36-47 | 990.4  (67.06) | 486.5  (32.94) |
| 48-59 | 1088  (71.76) | 428.3  (28.24) |
| **Place of delivery** |  |  |
| Home | 1580  (64.19) | 881.6  (35.81) |
| Hospital facility | 1821  (75.03) | 606  (24.97) |
| **Birth Order** |  |  |
| 1-3 | 4899  (70.97) | 2004  (29.03) |
| 4-6 | 549.2  (59.7) | 370.7  (40.3) |
| 7-10 | 30.33  (53.13) | 26.76  (46.87) |
| **Fever** |  |  |
| No | 3647  (69.89) | 1571  (30.11) |
| Yes | 1828  (68.81) | 828.7  (31.19) |
| **Cough** |  |  |
| No | 3469  (69.39) | 1530  (30.61) |
| Yes | 2005  (69.71) | 871.4  (30.29) |
| **Diarrhea** |  |  |
| No | 5198  (69.32) | 2300  (30.68) |
| Yes | 277  (73.22) | 10.3  (26.78) |
|  |  |  |

**Table 4: Distribution of child stunting in regional level**

|  |  |  |
| --- | --- | --- |
| **Variables** | **Child Stunting** | |
| **Not Stunted**  **N (%)** | **Stunted**  **N (%)** |
| **Area of residence** |  |  |
| Urban | 1560  (74.85) | 524.2  (25.15) |
| Rural | 3919  (67.61) | 1877  (32.39) |
| **Division** |  |  |
| Barisal | 299.7  (67.37) | 145.2  (32.63) |
| Chittagong | 1108  (67.99) | 521.5  (32.01) |
| Dhaka | 1472  (74.74) | 497.6  (25.26) |
| Khulna | 550.7 (74.49) | 188.6  (25.510) |
| Mymensingh | 437.7  (65.34) | 232.2  (34.66) |
| Rajshahi | 632.1  (69.12) | 282.3  (30.88) |
| Rangpur | 598.4  (69.88) | 258  (30.12) |
| Sylhet | 380.7  (57.96) | 276.2  (42.04) |

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**Figure 1:** Percentage ofchild stunting division wise in Bagladesh.

**Table 5: Factor associated with child stunting in the multivariable and multilevel model**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Covariates** | **Multivariable Model** | | **Multilevel Model** | |
|  | **OR (95% CI)** | P-value | **OR (95% CI)** | P-value |
| **Area of residence** |  |  |  |  |
| Urban | 1.01 (0.81-1.26) | 0.91 | 0.98 (0.73-1.31) | 0.88 |
| Rural | 1 |  | 1 |  |
| **Division** |  |  |  |  |
| Dhaka | 1 |  | 1 |  |
| Barisal | 1.18 (0.85-1.64) | 0.32 | 1.49 (0.92-2.39) | 0.1 |
| Chittagong | 1.21 (0.88-1.65) | 0.24 | 1.65 (1.04-2.62) | 0.04 |
| Khulna | 1.03 (0.73-1.46) | 0.85 | 1.09 (0.66-1.82) | 0.73 |
| Mymensingh | 1.41 (1.02-1.95) | 0.04 | 1.86 (1.15-3.01) | 0.01 |
| Rajshahi | 1.28 (0.91-1.8) | 0.16 | 1.19 (0.72-1.96) | 0.5 |
| Rangpur | 1.17 (0.85-1.61) | 0.34 | 1.43 (0.88-2.32) | 0.15 |
| Sylhet | 1.46 (1.09-1.96) | 0.01 | 2.2 (1.43-3.38) | <0.001 |
| **Mothers’ Education** |  |  |  |  |
| No education | 1.36 (0.9-2.05) | 0.14 | 1.63 (0.97-2.74) | 0.07 |
| Primary | 1.45 (1.07-1.98) | 0.02 | 1.86 (1.25-2.75) | <0.001 |
| Secondary | 1.39 (1.05-1.83) | 0.02 | 1.75 (1.23-2.49) | <0.001 |
| Higher secondary or above | 1 |  | 1 |  |
| **Fathers’ Education** |  |  |  |  |
| No education | 1.36 (0.9-2.05) | 0.14 | 2.19 (1.43-3.33) | <0.001 |
| Primary | 1.45 (1.07-1.98) | 0.02 | 1.93 (1.34-2.76) | <0.001 |
| Secondary | 1.39 (1.05-1.83) | 0.02 | 1.44 (1.01-2.04) | 0.04 |
| Higher secondary or above | 1 |  | 1 |  |
| **Mothers’ Work Status** |  |  |  |  |
| No |  |  | 1 |  |
| Yes | 1.01 (0.85-1.21) | 0.87 | 0.96 (0.78-1.2) | 0.75 |
| **Household Heads’ Occupation** |  |  |  |  |
| Business | 1 |  | 1 |  |
| Jobless | 1.07 (0.35-3.23) | 0.9 | 0.94 (0.28-3.13) | 0.92 |
| Farmer | 1.19 (0.9-1.57) | 0.23 | 1.28 (0.9-1.82) | 0.17 |
| Agriculture | 1.15 (0.84-1.57) | 0.39 | 1.22 (0.8-1.86) | 0.35 |
| Others | 1.08 (0.9-1.3) | 0.4 | 1.02 (0.8-1.28) | 0.89 |
| **Wealth Index** |  |  |  |  |
| Poor | 1.27 (1-1.62) | 0.05 | 1.5 (1.11-2.05) | 0.01 |
| Middle | 1.22 (0.98-1.52) | 0.08 | 1.35 (1.01-1.81) | 0.04 |
| Rich | 1 |  | 1 |  |
| **Methods of delivery** |  |  |  |  |
| Normal | 1 |  | 1 |  |
| Caesarean | 1.29 (1.08-1.55) | 0.01 | 1.3 (1.03-1.63) | 0.03 |
| **Iron tablet during pregnancy** |  |  |  |  |
| Yes | 1 |  | 1 |  |
| No | 1.01 (0.85-1.21) | 0.87 | 1.35 (1.06-1.71) | 0.01 |
| **No. of Antenatal Care** |  |  |  |  |
| Less or equal 4 times | 1.04 (0.89-1.22) | 0.62 | 1.05 (0.85-1.28) | 0.67 |
| Greater than 4 times | 1 |  | 1 |  |
| **Prenatal Care** |  |  |  |  |
| Yes | 1.09 (0.84-1.43) | 0.51 | 1.14 (0.8-1.62) | 0.48 |
| No | 1 |  | 1 |  |
| **Delivery assistance** |  |  |  |  |
| Yes | 1.01 (0.85-1.21) | 0.87 | 20.74(0.58-73.5) | 0.1 |
| No | 1 |  | 1 |  |
| **Mass Media facility** |  |  |  |  |
| No | 1.29 (1.08-1.55) | 0.01 | 1.01 (0.81-1.26) | 0.93 |
| Yes | 1 |  | 1 |  |
| **Birth Order** |  |  |  |  |
| 1-3 | 1 |  | 1 |  |
| 4-6 | 0.99 (0.78-1.26) | 0.92 | 1 (0.75-1.35) | 0.98 |
| 7-10 | 1.29 (0.63-2.64) | 0.49 | 1.45 (0.61-3.45) | 0.4 |
| **Children Age** |  |  |  |  |
| 0-11 | 1 |  | 1 |  |
| 12-23 | 2.14 (1.76-2.58) | <0.001 | 2.54 (2.01-3.2) | <0.001 |
| 24-35 | 2.69 (2.21-3.27) | <0.001 | 3.22 (2.51-4.14) | <0.001 |
| 36-47 | 1.98 (1.63-2.39) | <0.001 | 2.24 (1.80-2.79) | <0.001 |
| 48-59 | 1.52 (1.25-1.84) | <0.001 | 1.65 (1.34-2.04) | <0.001 |
|  |  |  |  |  |

**Table 6:** Goodness of fit table

|  |  |  |
| --- | --- | --- |
|  | Multivariable logistic regression Model | Multilevel mixed-effects logistic regression model |
| Area Under ROC Curve (95% CI) | 0.6793(0.66660, 0.69209) | 0.7117(0.69933, 0.72399) |
| AIC | 5297.601 | 5296.675 |
| BIC | 5508.413 | 5503.919 |
| Log-likelihood | -2615.337 | -2616.8 |