Title:

Methods:

**Ethics approval**

Our study was based on an analysis of public domain health survey datasets obtained from BDHS 2017, which is freely available online, with all identifying information removed. Informed consent was obtained from participants while interviewing them. The Bangladesh Demographic and Health Survey (BDHS) 2017 was reviewed and approved by the ICF Macro Institutional Review Board and the National Research Ethics Committee of the Bangladesh Medical Research Council. This survey was conducted by the National Institute of Population Research and Training (NIPORT) of the Ministry of Health and Family Welfare and implemented by Mitra and Associates, Bangladesh.

**Data source and study design**

We used the latest available BDHS 2017 data for our study. There 8347 mother-child pairs information was given which represents the seven regions (Chittagong, Dhaka, Barisal, Sylhet, Rajshahi, Khulna, Rangpur) in Bangladesh. Districts are taken as the main sampling strata for the sample. Among them, the number of children living with their mothers didn’t have birth records and other criteria removed (n=5938) and 2409 children were included [22].

**Sampling**

BDHS sample was stratified and selected into two stages. In the first stage, 675 enumeration areas (EAs) were selected with probability proportional to the EA’s size with 227 EAs in the urban areas and 448 EAs in rural areas. Then in the second stage of sampling, a systemic sample selection of 20250 households (6810 in urban and 13440 in rural) on an average of 30 households per EA was made using systematic sampling. Due to the difference in the proportional allocation of samples and response rate among samples in the division, urban and rural areas, the sample weight was adjusted to ensure the representativeness of the survey results at the national level. Eliminates the underestimation of variability in estimates by weighing data for under-sampling and oversampling within the strata for clustering in the sample. A detailed description of the weighting procedure can be found in the BDHS report [22].

**Outcome variable**

Short birth intervals (of less than 24 months) can lead to harmful outcomes for both newborns and their mothers, such as preterm birth, low birth weight, death, etc. In this study, we considered low birth weight and pre-term birth as outcome variables [22]. For study purposes, firstly, we put 1 (Yes) if the mother reported that the child was born with a low birth weight and pre-term birth, otherwise 0 (No).

**Exposure variable**

Solid fuel, which was ascertained by the type of fuel used for cooking or heating was the exposure variable of interest in this study. Each household's type of cooking fuel was collected by the BDHS. 'What type of fuel does your home primarily use for cooking?' survey respondents were asked [22]. Fuel types were classified into coal/lignite, charcoal, wood, straw/shrubs/grass, agricultural crops, animal dung, electricity, and liquid petroleum gas/natural gas/biogas. The exposure variable was a binary variable that indicates types of cooking fuel: clean fuel versus solid fuel. Coal/lignite, charcoal, wood, straw/shrubs/grass, agricultural crops, and animal dung were considered as solid fuels. The use of electricity, and liquid petroleum gas/natural gas/biogas were classified as clean fuels. Fuel type variable is coded as 1 if the household use clean fuel, otherwise 0 (solid fuel).

**Potential confounding variables**

By reviewing the valid literature, the most potentially related and assumed variables associated with low birth weight and pre-term birth were included in this study. Household-related factors (place of residence, region of the country, media accessibility (possession of television or radio), source of drinking water, toilet facility, wealth index, electricity accessibility, type of flooring material, type of roof material, type of wall material, and number of household member), parents/caregivers related factors (having a health card (vaccination), mother’s age, mother’s education level, mother’s BMI, number of living children, mother’s occupation, mother’s work for, household head’s occupation, household head’s education, and type of household head’s education), and child-related factors (child’s age, sex of child, birth order, place of delivery, weight at birth, delivery by C-section, season of birth, medication for intestinal parasites, vitamin A supplementation, and nutritional status (stunting and wasting)).

Respondents were asked how often they listened to the radio or watched television in this study. Those who responded at least once a week are considered regularly exposed to that form of media [22]. Piped water (piped water, piped into a dwelling, piped to yard/plot, public tap/standpipe), tube well (tube well water, tube well or borehole), and other sources of drinking water were identified (e.g. rainwater, river, protected or unprotected well) [26]. Improved (flush toilet, flush to piped sewer system, flush to septic tank, flush to pit latrine, pit latrine with slab, and ventilated improved pit latrine), shared (improved but shared with other households), and not improved (no flush toilet, no flush to piped sewer system, no flush to the septic tank, no flush to the septic tank, no flush to septic tank, no flush to the septic tank, no flush to the septic tank (e.g. hanging toilet, open pit) [27]. Wealth index was re-categorized into high economic class (upper 20% asset value), middle economic class (middle 40% asset value) and low economic class (lower 40% asset value) [28]. The survivor also observed the main material of the floor/roof/wall of the dwelling. The floor/roof/wall was classified as natural (earth/sand and dung), rudimentary (wood planks and palm/bamboo) and finished (vinyl or asphalt strips, ceramic tiles, cement, and carpet) [22].

The BDHS obtained vaccination coverage data in two methods in 2017-18: from immunization cards provided to interviewers and from mothers' verbal remarks. The interviewers transcribed the vaccination dates straight into the questionnaire if the cards were available. The respondent was asked to recollect the immunizations administered to her child if there was no vaccination card for the child or if a vaccine had not been noted as being given on the vaccination card [22]. Mother's/household head’s educational level was also divided into three groups: no education, primary and secondary complete or higher (completing at least grade 10). Mother's BMI was classified as underweight (BMI less than 18.5 kg/m2), normal (BMI 18.5-24.9 kg/m2), overweight (BMI 25-29.9 kg/m2) and obese (BMI higher than 30 kg/m2) [29]. Mother's/household head’s occupation categorized as agricultural/skilled worker (farming/agricultural work and semi-skilled labor/service), household/unskilled worker (unskilled labor, home-based manufacturing, domestic service, and other), industrial worker (Professional/technical, business, factory work or blue-collar service, poultry or cattle raising).

In this study, weight at birth classified as low if the weight of child was less than 2500 grams and normal if greater than 2500 grams. For measuring a child's nutritional status, two anthropometric indices, height-for-age and weight-for-height z-score, were used as recommended by the WHO [30]. The z-score implies how many standard deviations a given value is apart from the mean, and it is usually used to standardize data. In this case, the z-score was utilized to compare stunting and wasting in children under the age of five across gender and age categories. A child was considered wasted if the weight-for-height z-score was less than -2 and stunted if the height-for-age z-score was less than -2. Some of the variables were re-categorized by combining two or more levels of individual variables.

**Statistical analyses**

Descriptive statistics were performed to show the distribution of variables. In this study, number and percentage were used for categorical variables. Chi square test was used to identify factors association with low birth weight and pre-term birth of the children. ‘P’ value <0.05 was taken as significant and ‘P’ value <0.001 was taken as highly significant. We fitted the design-based binary logistic regression [31] to assess the association between child low birth weight and pre-term birth with types of cooking fuel in household. For the adjusted association, the model was adjusted with all selected variables. The crude odds ratio (COR) and adjusted odds ratio (AOR) were calculated, along with the 95% confidence interval (CI) and p-values. The relationship between low birth weight and pre-term birth with every other considered exposure/covariate was investigated individually by using bivariate analysis, mainly the Chi-squared test and bivariate logistic regression model. We used the multivariable logistic regression model to observe how exposure variable acts when the effect of all other risk factors associated with low birth weight and pre-term birth are adjusted and vice versa. Considering cluster variation in our analysis, we fitted a multilevel model using the survey binary logistic regression model. The statistical analyses and data management for this study had been carried out using R (survey package).

**Model assessment**

To check the predictive accuracy of the final model, the area under the curve (AUC) of the receiver operating characteristic curve was used (Table 5). We also used the Hosmer and Lemeshow goodness-of-fit test to provide an overview of the overall fit of the final model (Table 5).

**Results**

Table 1 shows the frequency distribution of different confounding factors of children, parental and household characteristics between LBW and preterm birth including p-value from the Chi-Square test. We found that 39.47% of women belonging to the age group greater than 25 years, were more likely to give exclusive breastfeeding to their children. Chittagong division had the highest exclusive breastfeeding babies among all other divisions, with a percentage of 20.27%. The lowest percentage was recorded for EBF in the Barisal division, 9.87%. Comparing mothers’ current working situation, it can be said that 15.73% of working women are more interested to give her child exclusive breastfeeding. Rich household’s child has the highest rate of exclusive breastfeeding and it is 40.53%. Calculating body mass index, it can be said that 61.76% of children are raised in normal-weight mother and they got the highest exclusive breastfeeding according to obese and under-weight mothers.

Table 1: Frequency distribution and Chi-square test for identifying factors associated with Low Birth Weight (LBW).

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Variable** | **Category** | **LBW** | | **P-value** | **Pre-term birth** | | |
| **No** | **Yes** | **No** | **Yes** | **P-value** |
| **n (%)** | **n (%)** | **n (%)** | **n (%)** |  |
| **Children Characteristics** | | | | | | | |
| Age of Child (in months) | 24-59 | 624 (85.92) | 102 (14.08) | 0.048 | 4250 (87.37) | 615 (12.63) | 0.001 |
| 12-23 | 645 (83.38) | 129 (16.62) |  | 1488 (88.54) | 193 (11.46) |  |
| 0-11 | 691 (83.92) | 132 (16.08) |  | 1551 (87.35) | 225 (12.65) |  |
| Sex of Child | Male | 1101 (85.22) | 191 (14.78) | 0.058 | 4014 (87.59) | 569 (12.41) | 0.036 |
|  | Female | 916 (82.00) | 201 (18.00) | 3672 (87.65) | 517 (12.35) |  |
| Birth Order Number | 1-3 | 1908 (84.34) | 354 (15.66) | .004\* | 6730 (87.77) | 938 (12.23) | 0.019 |
|  | 4-6+ | 108 (74.19) | 38 (25.81) |  | 956 (86.59) | 148 (13.41) |  |
| Drugs for Intestinal Parasites in Last 6 Months | No | 1376 (85.05) | 242 (14.95) | 0.276 | 4349 (87.61) | 615 (12.39) | 0.979 |
| Yes | 591 (83.05) | 121 (16.95) | 2998 (87.63) | 423 (12.37) |  |
| Acute Respiratory Infection | No | 1953 (83.71) | 380 (16.29) | 0.083 | 7457 (87.54) | 1062 (12.46) | 0.043 |
| Yes | 63 (84.42) | 12 (15.58) |  | 229 (90.27) | 25 (9.73) |  |
| Ever had Vaccination | Yes | 509 (84.89) | 91 (15.11) | 0.681 | 1173 (88.36) | 155 (11.64) | 0.482 |
|  | No | 103 (83.22) | 21 (16.78) |  | 287 (86.78) | 44 (13.22) |  |
| Vitamin A | No | 566 (82.89) | 117 (17.11) | 0.219 | 1976 (87.46) | 283 (12.54) | 0.789 |
|  | Yes | 1406 (85.16) | 245 (14.84) | 5364 (87.70) | 752 (12.30) |  |
| Place of Delivery | Home | 191 (81.99) | 42 (18.01) | 0.002 | 2357 (88.25) | 314 (11.75) | 0.048 |
|  | Hospital | 1825 (83.92) | 350 (16.08) |  | 2345 (87.93) | 322 (12.07) |  |
| Delivery by Caesarean Section | Caesarean | 1278 (85.20) | 222 (14.80) | .025\* | 1551 (88.76) | 196 (11.24) | 0.054 |
|  | Non-Caesarean | 733 (81.28) | 169 (18.72) |  | 3146 (87.79) | 438 (12.21) |  |
| Stunting | No | 1455 (87.63) | 205 (12.37) | <.001\* | 4738 (87.48) | 678 (12.52) | 0.017 |
|  | Yes | 392 (74.14) | 137 (25.86) |  | 2112 (87.93) | 290 (12.07) |  |
| Wasting | No | 1707 (84.83) | 305 (15.17) | 0.053 | 6263 (87.65) | 882 (12.35) | 0.042 |
|  | Yes | 134 (78.55) | 37 (21.45) |  | 574 (87.16) | 85 (12.84) |  |
| Under Weight | No | 1732 (84.58) | 316 (15.42) | 0.013 | 6417 (87.64) | 905 (12.36) | 0.087 |
|  | Yes | 130 (79.54) | 33 (20.46) |  | 489 (87.41) | 70 (12.59) |  |
| **Parental Characteristics** | | | | | | | |
| Age in 5-Year Groups | 15-24 | 1103 (83.16) | 223 (16.84) | 0.004 | 3676 (88.08) | 498 (11.92) | 0.011 |
| 25-34 | 811 (84.60) | 148 (15.40) | 3422 (87.44) | 492 (12.56) |
| 35+ | 102 (83.10) | 21 (16.90) | 588 (85.85) | 97 (14.15) |
| Highest Educational Level | Higher | 594 (86.16) | 95 (13.84) | .007\* | 1186 (87.83) | 164 (12.17) | 0.046 |
| Secondary | 1060 (84.33) | 197 (15.67) | 3735 (87.91) | 514 (12.09) |
| No Education or Primary | 361 (78.45) | 99 (21.55) | 2765 (87.13) | 408 (12.87) |
| Type of School | School | 1797 (84.42) | 332 (15.58) | 0.466 | 6448 (87.71) | 903 (12.29) | 0.491 |
| Madrasha | 170 (82.24) | 37 (17.76) | 688 (88.66) | 88 (11.34) |
| BMI | Obese | 156 (88.88) | 20 (11.12) | 0.397 | 439 (86.41) | 69 (13.59) | 0.610 |
|  | Over Weight | 459 (83.78) | 89 (16.22) | 1559 (88.31) | 206 (11.69) |
|  | Normal Weight | 1119 (83.18) | 226 (16.82) | 4517 (87.67) | 635 (12.33) |
|  | Under Weight | 244 (84.02) | 46 (15.98) | 1037 (86.77) | 158 (13.23) |
| Mothers’ Occupation | Agriculture | 405 (84.31) | 75 (15.69) | 0.776 | 2188 (87.04) | 326 (12.96) | 0.640 |
|  | Do not Work | 1343 (83.32) | 269 (16.68) | 4410 (87.81) | 612 (12.19) |
|  | Industry | 266 (84.92) | 47 (15.08) | 1087 (87.99) | 148 (12.01) |
| Mothers’ Works for | Family | 369 (84.28) | 69 (15.72) | 0.882 | 1970 (86.93) | 296 (13.07) | 0.198 |
|  | Else | 152 (84.21) | 28 (15.79) | 662 (89.47) | 78 (10.53) |
|  | Self | 149 (85.95) | 24 (14.05) | 637 (86.50) | 99 (13.50) |
| Education of Household Head | Higher | 643 (87.58) | 91 (12.42) | .007\* | 1340 (88.68) | 171 (11.32) | 0.039 |
| Secondary | 724 (82.32) | 155 (17.68) | 2473 (87.43) | 355 (12.57) |
| No Education or Primary | 622 (81.31) | 143 (18.69) | 3716 (87.18) | 546 (12.82) |
| Household Head Occupation | Agriculture | 254 (83.55) | 50 (16.45) | 0.877 | 1507 (87.24) | 221 (12.76) | 0.86 |
|  | Do not Work | 45 (86.64) | 7 (13.36) | 186 (88.42) | 24 (11.58) |
|  | Industry | 1709 (83.66) | 334 (16.34) | 5976 (87.67) | 840 (12.33) |
| **Household Characteristics** | | | | | | | |
| Household Member | Below Median | 627 (82.79) | 130 (17.21) | 0.451 | 2581 (87.56) | 367 (12.44) | 0.921 |
|  | Above Median | 1389 (84.16) | 261 (15.84) |  | 5105 (87.65) | 720 (12.35) |  |
| Number of Living Children | ≤ 2 | 1683 (84.26) | 314 (15.74) | 0.385 | 5511 (87.60) | 780 (12.40) | 0.899 |
|  | 3-4 | 312 (81.19) | 72 (18.81) | 1863 (87.52) | 266 (12.48) |
|  | ≥ 5 | 22 (80.58) | 5 (19.42) | 312 (88.48) | 41 (11.52) |
| Division | Barisal | 91 (84.54) | 17 (15.46) | 0.069 | 430 (88.40) | 56 (11.60) | 0.003 |
|  | Chittagong | 348 (79.11) | 92 (20.89) | 1632 (89.31) | 195 (10.69) |
|  | Dhaka | 627 (84.36) | 116 (15.64) | 1960 (86.58) | 304 (13.42) |
|  | Khulna | 234 (84.57) | 43 (15.43) | 714 (89.16) | 87 (10.84) |
|  | Mymensingh | 159 (88.78) | 20 (11.22) | 645 (88.02) | 88 (11.98) |
|  | Rajshahi | 231 (83.96) | 44 (16.04) | 898 (88.03) | 122 (11.97) |
|  | Rangpur | 244 (86.18) | 39 (13.82) | 779 (84.60) | 142 (15.40) |
|  | Sylhet | 82 (79.65) | 21 (20.35) | 628 (87.18) | 92 (12.82) |
| Type of Place of Residence | Urban | 694 (83.52) | 137 (16.48) | 0.059 | 2124 (88.02) | 289 (11.98) | 0.025 |
|  | Rural | 1322 (83.84) | 255 (16.16) | 5562 (87.46) | 797 (12.54) |
| Media | No | 615 (81.25) | 142 (18.75) | .043 | 3514 (87.45) | 504 (12.55) | 0.088 |
|  | Yes | 1092 (85.11) | 191 (14.89) | 3260 (87.78) | 454 (12.22) |
| Wealth Index | Rich | 1139 (85.38) | 195 (14.62) | 0.094 | 3039 (87.80) | 422 (12.20) | 0.096 |
| Middle | 375 (81.90) | 83 (18.10) | 1429 (86.79) | 218 (13.21) |
| Poor | 502 (81.52) | 114 (18.48) | 3218 (87.81) | 446 (12.19) |
| Type of Cooking Fuel | Fossil Fuel | 523 (85.38) | 90 (14.62) | 0.002 | 1458 (87.96) | 200 (12.04) | 0.006 |
| Biomass Fuel | 1184 (83.12) | 240 (16.88) | 5311 (87.53) | 757 (12.47) |
| Source of Drinking Water | Piped Water | 183 (84.41) | 34 (15.59) | 0.933 | 459 (87.51) | 66 (12.49) | 0.268 |
| Tube Well | 1484 (83.55) | 292 (16.45) | 6098 (87.49) | 872 (12.51) |
| Other | 39 (85.09) | 7 (14.91) | 216 (91.42) | 20 (8.58) |
| Type of Toilet Facility | Modern Toilet | 701 (83.99) | 134 (16.01) | 0.774 | 2032 (88.12) | 274 (11.88) | 0.421 |
| Other | 1006 (83.46) | 199 (16.54) | 4742 (87.39) | 684 (12.61) |
| Season | Summer | 496 (84.84) | 89 (15.16) | 0.023 | 2046 (89.45) | 241 (10.55) | .039\* |
| Autumn | 447 (82.49) | 95 (17.51) | 1713 (87.00) | 256 (13.00) |
| Winter | 505 (81.56) | 114 (18.44) | 1840 (86.48) | 288 (13.52) |
| Spring | 568 (85.80) | 94 (14.20) | 2087 (87.38) | 301 (12.62) |

Table 2 represents the percentage distribution of different confounding factors of the child’s characteristics by type of Exclusive-Breastfeeding. Among 632 children it can be shown that 27.20% child born by C-section delivery and they get EBF. On another side, 69.33% of children were EBF and having an average size at birth. As age increases EBF was decreasing in a significant rate, 39.47% of children in our country are of 0-1 months are exclusively breastfed somewhere it can be shown that 38.40% of children having 2-3 months age are exclusively breastfed and this percentage (22.13%) is lowest in the higher age group 4-5 months of the child.

Table 3:

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **LBW** | | | | **Pre-term birth** | | | |
| **Covariates** | **Unadjusted OR (95% CI)** | **P-value** | **Adjusted OR (95% CI)** | **P-value** | **Unadjusted OR (95% CI)** | **P-value** | **Adjusted OR (95% CI)** | **P-value** |
| **Place of residence** |  |  |  |  |  |  |  |  |
| Urban | - |  |  |  | - |  |  |  |
| Rural | 0.98 (0.75-1.27) | 0.864 | 1.08 (0.49-2.38 | 0.840 | 1.05 (0.91-1.22) | 0.497 | 0.3 (0.11-0.82) | 0.02 |
| **Media** |  |  |  |  |  |  |  |  |
| No | - |  |  |  | - |  |  |  |
| Yes | 0.75 (0.57-1.00) | 0.051 | 1.22 (0.46-3.23) | 0.687 | 0.97 (0.83-1.13) | 0.691 | 2.72 (1.12-6.61) | 0.027 |
| **Sources of Drinking Water** |  |  |  |  |  |  |  |  |
| Piped water | - | - |  |  | - | - |  |  |
| Tube-well | 1.07 (0.64-1.77) | 0.803 | 1.25 (0.33-4.7) | 0.74 | 1.00 (0.75-1.34) | 0.987 | 0.87 (0.13-5.78) | 0.881 |
| Others | 0.95 (0.35-2.57) | 0.918 | 2.48 (0.38-16.24) | 0.342 | 0.66 (0.39-1.10) | 0.109 | 0.81 (0.06-11.58) | 0.874 |
| **Types of Toilets** |  |  |  |  |  |  |  |  |
| Modern | - | - |  |  | - | - |  |  |
| Others | 1.04 (0.78-1.38) | 0.785 | 0.52 (0.23-1.18) | 0.117 | 1.07 (0.91-1.26) | 0.418 | 2.21 (0.57-8.61) | 0.251 |
| **Types of Fuel** |  |  |  |  |  |  |  |  |
| Fossil | - | - |  |  | - | - |  |  |
| Biomass | 1.19 (0.84-1.67) | 0.328 | 2.21 (0.86-5.65) | 0.098 | 1.04 (0.85-1.27) | 0.693 | 0.86 (0.15-4.79) | 0.858 |
| **Electricity** |  |  |  |  |  |  |  |  |
| No | - | - |  |  | - | - |  |  |
| Yes | 0.66 (0.43-1.01) | 0.061 | 0.55 (0.21-1.45) | 0.229 | 1.01 (0.82-1.25) | 0.916 | 0.51 (0.19-1.38) | 0.185 |
| **Wall Materials** |  |  |  |  |  |  |  |  |
| Natural | - | - |  |  | - | - |  |  |
| Rudimentary | 0.84 (0.32-2.17) | 0.721 | 3.09 (0.43-22.14) | 0.26 | 0.99 (0.85-1.16) | 0.924 | 1.14 (0.51-2.55) | 0.74 |
| Finished | 0.67 (0.40-1.11) | 0.119 | 1.59 (0.45-5.66) | 0.471 |  |  |  |  |
| **HH Members** |  |  |  |  | - | - |  |  |
| Below median | - | - |  |  | 1.16 (0.67-1.75) | 0.489 | 0.66 (0.2-2.13) | 0.484 |
| Above median | 0.91 (0.69-1.20) | 0.482 | 0.56 (0.28-1.11) | 0.098 |  |  |  |  |
| **Vaccination Status** |  |  |  |  | - | - |  |  |
| Yes | - | - |  |  | 0.99 (0.81-1.21) | 0.939 | 0.98 (0.3-3.16) | 0.968 |
| No | 1.13 (0.61-2.21) | 0.691 | 0.79 (0.27-2.29) | 0.66 | 1.07 (0.86-1.32) | 0.562 | 1.29 (0.41-4.06) | 0.66 |
| **HH Occupation** |  |  |  |  |  |  |  |  |
| Agriculture | - | - |  |  | - | - |  |  |
| Industry | 0.99 (0.69-1.43) | 0.964 | 0.9 (0.1-8.01) | 0.924 | 0.78 (0.59-1.03) | 0.082 | 0.9 (0.28-2.9) | 0.862 |
| Unemployed | 0.78 (0.30-2.07) | 0.621 | 1.33 (0.46-3.89) | 0.595 | 1.03 (0.80-1.35) | 0.782 | 2.78 (1.12-6.9) | 0.028 |
| **Gender of Children** |  |  |  |  |  |  |  |  |
| Male | - | - |  |  | - | - |  |  |
| Female | 1.27 (0.99-1.61) | 0.056 | 0.82 (0.44-1.56) | 0.551 | 0.91 (0.70-1.20) | 0.511 | 1.59 (0.46-5.42) | 0.46 |
| **Birth Order** |  |  |  |  |  |  |  |  |
| 1-3 | - | - |  |  | - | - |  |  |
| 4+ | 1.87 (1.23-2.85) | 0.003 | 4.22 (1.41-12.66) | 0.01 | 0.99 (0.86-1.14) | 0.936 | 0.98 (0.44-2.18) | 0.955 |
| **Place of Delivery** |  |  |  |  |  |  |  |  |
| Home | - | - |  |  | - | - |  |  |
| Hospital | 0.87 (0.57-1.33) | 0.524 | 1.77 (0.37-8.52) | 0.475 | 1.11 (0.88-1.40) | 0.368 | 0.48 (0.15-1.51) | 0.205 |
| **C Section** |  |  |  |  |  |  |  |  |
| Yes | - | - |  |  | - | - |  |  |
| No | 1.33 (1.03-1.70) | 0.027 | 2.02 (1.01-4.02) | 0.046 | 1.03 (0.85-1.25) | 0.760 | 0.95 (0.31-2.87) | 0.925 |
| **Drugs for Intestinal Parasites**  **(Last 6 Months)** |  |  |  |  |  |  |  |  |
| No | - | - |  |  | - | - |  |  |
| Yes | 1.16 (0.87-1.56) | 0.319 | 2.38 (1.21-4.65) | 0.012 | 1.10 (0.89-1.36) | 0.387 | 1.49 (0.39-5.68) | 0.556 |
| **Vitamin A** |  |  |  |  |  |  |  |  |
| No | - | - |  |  | - | - |  |  |
| Yes | 0.84 (0.64-1.12) | 0.234 | 1.09 (0.49-2.41) | 0.831 | 1.00 (0.86-1.15) | 0.979 | 0.47 (0.19-1.15) | 0.096 |
| **Wasting** |  |  |  |  |  |  |  |  |
| No | - | - |  |  | - | - |  |  |
| Yes | 1.53 (0.99-2.35) | 0.053 | 2.29 (0.76-6.91) | 0.14 | 0.98 (0.83-1.15) | 0.789 | 0.77 (0.31-1.94) | 0.575 |

Model assessment

Table 4 demonstrates the fitting goodness of four regression models (PR, NB, ZIP, and ZINB). The model with the smallest Log-likelihood, AIC, AICc, and BIC was ZINB regression among the four models considered. The ZINB model had the smallest log-likelihood, AIC, AICc, and BIC, suggesting the best fit of the data (table 3).

ZINB was the best model for our data according to both Vuong statistics and goodness of fit statistics, respectively. In this regard, we used the ZINB model to estimate the crude (unadjusted) risk ratio (CRR) and adjusted risk ratios (ARRs) for evaluating the association between EBF and childhood diseases. Table 5 shows the crude risk ratio (CRR) for developing diseases. Here we found that the EBF was significantly associated the childhood diseases (CRR 1.24; 95% CI 1.01-1.57).

Table 6 shows the association between EBF and early childhood diseases when models adjusted for possible confounding factors. For instance, after adjusting all other factors, the expected disease count for Non-EBF babies was 1.27 times (ARR 1.27, 95% CI 1.01–1.60) higher than EBF babies and the association was statistically significant. The risk of having diseases is 1.73 times (ARR 1.74, 95% CI: 1.17-2.56) and 1.74 times (ARR 1.74, 95% CI: 1.23-2.71) more likely for living child in Chittagong and Sylhet compared to Barisal, respectively. Mother’s education has also been found as an important factor for childhood diseases. It shows that children belonging to mothers who had no education was a higher risk of childhood diseases than the children of higher educated mothers. That is, they were 1.47 times (95% CI: 0.95-2.31) more likely to suffer from diseases. It is worthwhile to mention that children of the mother with advanced in media access were 1.30 times (95% CI 0.99-1.70) more likely to have diseases compared to the children who raise in the family with lagging behind mothers in media access. The results also show that the risk of diseases for the children of the poorest household was 1.48 times (ARR: 1.48, 95% CI: 1.02-2.17) more likely than those who have a family with rich wealth status. The results also show that the risk of diseases for the children of the overweight mother were 1.53 times (ARR: 1.53, 95% CI: 1.16-2.01) more likely than those who are normal weight. The risk of having diseases is 1.99 times (ARR 1.97, 95% CI: 1.44-2.75) and 1.69 times (ARR 1.69, 95% CI: 1.22-2.39) more likely for 4-5 months and 2-3 months of the child compared to 0-1 months of the child, respectively. However, according to adjusted LR statistics, early childhood diseases were not significantly associated with mother’s age, geographical location, residence, mother’s education, mother’s working status, father’s occupation, mass media, wealth status, household members, C-section, child’s sex, size of child and religion (S2 Table).

**Hosmer and Lemeshow goodness of fit (GOF) test**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **LBW** | | | **Pre-term birth** | | |
| **Test Statistic** | **d.f.** | **p-value** | **Test Statistic** | **d.f.** | **p-value** |
| X-squared = 4.3246 | 8 | 0.8267 | X-squared = 6.4929 | 8 | 0.5922 |
| **ROC-curve:** AUC value= 0.6830 | | | **ROC-curve:** AUC value= 0.7318 | | |

**ROC**

|  |  |
| --- | --- |
| **LBW** | **Pre-term birth** |
| **Chart, line chart  Description automatically generated** | **Chart, line chart  Description automatically generated** |