**Association between exclusive breastfeeding and common childhood diseases in Bangladesh**

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**ABSTRACT**

Childhood diseases in developing countries are a big threat to child survival. Previous studies reported that breastfed children have better health than non-breastfed children and identified several factors that have a significant relation to breastfeeding. However, research on the area of breastfeeding and childhood diseases is scarce. We aimed to assess the association between exclusive breastfeeding (EBF) and common childhood diseases (e.g., diarrhea, blood in stools, fever, cough, breathing problems) in Bangladesh. We used the 2014 Bangladesh Demographic & Health Survey (BDHS) data, which is the latest available nationally representative data. After inclusion and exclusion criteria, we considered 632 children aged under 6 months. The outcome variable was created using childhood diseases and important confounding factors such as the mother’s age, geographical location, area of residence, mother’s educational level mother’s current employment status, father’s occupation, religion, mass media access, wealth status, household members, age of the child, type of delivery of the child, size of child at birth, weight at birth during the survey and child’s sex were considered. We estimated crude and adjusted risk ratio (RR) using different count data analysis models (e.g., zero-inflated negative binomial (ZINB)). We found 55.3% of children belong to EBF (exclusive breastfed). Non-EBF children compared to EBF were expected to have a risk of 1.27 (RR 1.27, 95% CI 1.01–1.60, p = 0.045) times greater for developing diseases. Moreover, the risk of a child getting affected by diseases was more acute if the mothers' age lies between 15-19 years (1.10, 95% CI: 0.85-1.42) and overweight (1.53, 95%CI: 1.16,2.01). Furthermore, children of mothers having no educational background are facing a higher risk (1.47, 95% CI: 0.95-2.31) than the uneducated mother. Our study shows a significant inverse association between EBF and common childhood diseases in Bangladesh. To reduce common childhood diseases, a mother should be conscious about the benefit of exclusive breastfeeding to their infants.

**Keywords:** exclusive breastfeeding, childhood disease; survey; BDHS; children under 6 months

**INTRODUCTION**

Breastfeeding is a biological common diet and the safest option to ensure good health protects from diseases and the ideal growth of young children (Protection, 2019; Sankar et al., 2015). Breastfeeding has frequent health benefits for both the mother and child as it contains nutrients, antioxidants, hormones and antibodies (Oddy, 2017). Several national and international organizations (e.g. WHO) indorse exclusive breastfeeding (i.e. children received only breast milk) for the first six months (Santos et al., 2016) and is also recommended for two or more years as it related to adolescent intelligence (Mortensen et al., 2002; Victora et al., 2015). Only pneumonia and diarrhea are accounted for 15% and 9%, respectively, of the 6.3 million under-five deaths that occurred globally in 2013 (Fischer Walker et al., 2013). These two leading infectious causes of death in children under age 5 worldwide, responsible for more than 1.5 million deaths annually (Leung et al., 2016).

Breastfeeding can reduce bronchial asthma, atopic dermatitis (Gdalevich et al., 2001), allergic rhinitis (Bloch et al., 2007), type 1 diabetes mellitus (Bloch et al., 2007), gastrointestinal infections as it contains lactating, secretary IGA, T and B lymphocytes, bacteriolytic lactoferrin, oligosaccharide, and human milk glycans (Bloch et al., 2007). It has advantages, for an inferior risk of acute otitis media, lower risk of dental malocclusion, breathing contaminations, atopic dermatitis, necrotizing enterocolitis, unexpected infant death disorder,  maternal lower risk of breast and ovarian cancer and type 2 diabetes mellitus (T2DM) following gestational diabetes (Horta et al., 2015; Smith et al., 2017; Uwaezuoke et al., 2017).

The global rates of breastfeeding remain low and show only 45% of the world's newborns are put to the breast within 1 hour of birth; 40% infants aged 6 months or less are exclusively breastfed and only 45% of children continue to be breastfed during their first two years of life (Ashmore, 2019; Protection, 2019). In south Asian countries, the average rate of exclusive breastfeeding is 54% and in Bangladesh, it is about 55% (UNICEF, 2019).

Childhood diseases and mortality in children is high in Bangladesh. The mortality of the child remains high at 85 in 1000 live births. Pneumonia, ARI, diarrhea, malnutrition, and measles are the major childhood diseases and account for more than half (52%) of these deaths (Arifeen et al., 2004; Baqui et al., 2007). In Bangladesh, Pneumonia is responsible for around 28% of the deaths of children under five years of age

In Bangladesh, many studies have been conducted in anticipation of monitored breast milk (Hossain et al., 2018; M. A. (Bangladesh A. for R. D. C. (Bangladesh)) Rahman, 1983), child feeding practice (Hossain et al., 2018; Mat Min & Hossain, 2019; Mulder-Sibanda & Sibanda-Mulder, 1999; Piwoz & Huffman, 2015; Rollins et al., 2016), and factors correlated with breastfeeding and/or exclusive (Afrose et al., 2012; Ariful Islam et al., 2019; F. R. Chowdhury et al., 2018; Joshi et al., 2014). To our knowledge so far, there was no nationwide extensive research to assess the association between breastfeeding and general childhood diseases in Bangladesh. Therefore, we aimed to assess the association between EBF and common childhood diseases (e.g. diarrhea, blood in stools, fever, cough, breathing problem and problems in the chest) in Bangladesh.

**METHODS**

**Ethics approval**

Our study was based on analysis of public domain health survey datasets obtained from BDHS 2014, 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) 2014 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 (Yun et al., 2013).

**Data source and study design:**

We used the latest available BDHS 2014 data for our study. There 7886 number of 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 mother is 7500 and about 1236 children don’t live with their mother. Age between 0-5 months (632 children) was selected as a sample and 6868 children greater than six months are excluded (Figure 1).

**Sampling:**

BDHS sample was stratified and selected into two stages. In the first stage, 600 enumeration areas (EAs) were selected with probability proportional to the EA’s size with 207 EAs in the urban areas and 393 EAs in rural areas. Then in the second stage of sampling, a systemic sample selection of 17989 households (6210 in urban and 11779 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 (NIPORT, 2016).

**Outcome variable:**

In this study, common childhood diseases were taken as an outcome variable. A child was identified as suffering from diseases if their mother reported that the child had diarrhea, blood in stools, fever, cough, breathing problems, a problem in chest or problem in the nose in the two weeks before the survey. For study purposes, firstly, we put 1 if their mother reported that the child had a specific disease, otherwise 0. Then, we considered the outcome variable by counting all these early diseases.

**Exposure variable:**

During the survey, mothers were asked: whether the baby is still breastfeeding; Breastfeeding period; And if other solid or liquid foods were given during the last 24 h rather than breastfeed. The exposure variable was a binary variable that indicates types of breastfeeding: exclusive breastfeeding (EBF) versus non-exclusive breastfeeding (non-EBF), within the first six months of a child’s life. The EBF was considered only mothers breastfed and who did not provide any supplements for the first six months of their child's life, NOT even water. BDHS collects exclusive breastfeeding from mothers by recall method (Yun et al., 2013). EBF variable is coded as 1 if the child takes EBF, otherwise 0 (non-EBF).

**Potential confounding variables:**

In this study, maternal age (15–19 years, 20–24 years, 24–29 years, 30–34 years, ≥35 years), regions (Barisal, Chittagong, Dhaka, Khulna, Rajshahi, Rangpur, Sylhet), place of residence (rural, urban), current employment status (yes/no), maternal educational level (no education, primary, secondary, higher), fathers’ occupation (farmer, agriculture worker, businessman, others), religion of household (Islam, others), mass media access (yes/no), wealth status (richest, richer, middle, poorer, poorest), mother’s body mass index (BMI; underweight, normal, obese), number of household members (less equal five, greater than five) are assumed as possible confounding variables.

Moreover, C-section (yes/no), place of delivery (home/health facility), Sex of the child (male/female), Size of the children (at birth; (very large, large, average, very small, small) and Age of children (0-2 months, 3-6 months) are assumed possible confounding variables.

**Statistical analyses:**

***Bivariate analysis***

Distribution of selected confounding variables across the EBF and Non-EBF was shown by adjusting the sampling weight. Moreover, bivariate analysis was performed using cross-tabulation with Pearson's chi-square statistical test.

***Poisson Regression analysis***

To estimate the crude (unadjusted) risk ratio (CRR) and adjusted risk ratios (ARRs) for evaluating the causal association between EBF and childhood diseases, first, we developed a Poisson model as the outcome variable was a count data. The Poisson model assumes the logarithm of expected values (mean) that can be modeled into a linear form by some unknown parameters (Musa & Okumoto, 1984). As the Poisson model sometimes displayed substantial overdispersion (Dean & Lawless, 1989) we checked the validity of the Poisson model that fitted the data well.

***Identifying Overdispersion***

To check the overdispersion of the Poisson model, deviance and Pearson Chi-square goodness of statistics were considered. If the Goodness of fit parameters (values/df) greater than one indicates model misspecification or an over-dispersed (the variance larger than its mean) response variable. If it less than one may also indicate model misspecification or an under-dispersed (the variance is less than its mean) in the response variable (Muschelli et al., 2014). So, we checked the Goodness of fit parameters of the model then fit the data with a negative binomial (NB) regression model. Negative binomial (NB) regression accounts for overdispersion by adding dispersion (variance) parameter to the Poisson model. This model can accommodate increased variability (Lenth & Dobler, 2005).

***Test of Excess Zeros***

Another common extension of Poisson regression can address when the outcome variable has excess zeros (Xia et al., 2012). Although the NB can address overdispersion, in this study, this model may not be suitable for modeling data with a high percentage of zero counts. The zero-inflated Poisson (ZIP) model relates a logistic regression model with excess zeros by associating it with a traditional anomalous Poisson model (Weaver et al., 2015). There is a formal test statistic, the Vuong test which statistically determines whether the zero-inflation model (ZIP or ZINB) is a significant improvement over the Poisson model or the NB model. Thus, the Vuong test was taken to judge whether there were excessive zero counts for the ZIP regression than the Poisson model. Similarly, ZINB regression than the NB model (Vuong, 1989).

This statistic tests the null hypothesis that the two models (distributions) are equivalent, against the alternative that the two models are different. Then the Vuong statistic is defined as:

Now we define:

Where and are predicted probabilities of the corresponding models, respectively.

Where and denote the mean and standard deviation of the measurements mi (Woldeamanuel, 2018).

If the p-value is less than 0.05, we reject the null hypothesis that there's some significant difference between the models and a positive test statistic provides evidence of the superiority of model 1 over model 2, while a negative test statistic is evidence of the superiority of model 2 over model 1 (Blasco‐Moreno et al., 2019).

***Model assessment***

We used four models to assess for evaluating the causal association between EBF and childhood diseases. To find the best model, we used log-likelihood, AIC, AICc, and BIC values to compare all models; the lowest value of log-likelihood, AIC, AICc and BIC indicate a better fit of the data after accounting for model complexity (i.e., the number of model parameters). Using the best model, we reviewed the variability of the results from the models.

In the crude model, only the exposure (EBF vs non-EBF) was used and for the adjusted model, confounding variables with EBF were considered. All statistical analyses were performed by SAS and SPSS (IBM SPSS 25). In SAS, the survey analysis procedures command was used to allow for the adjustments of the complex survey design and to estimate weighted frequency for all explanatory variables.

**RESULTS**

Figure 2 presents the frequency plot of the outcome variable of childhood disease. The following bar chart compares the counts of diseases. Disease 0 are the highest (366) on children, followed by disease 1 to disease 4. The counts range from about 35 to 366. Notice that this variable showed an extremely right-skewed distribution with a spike at zero. That means, most data falls to the right, or positive side, of the graph's peak. We selected 632 children age under 6 months and 55.3% belong to EBF (Figure 3). Notice that this variable showed an extremely right-skewed distribution with a spike at zero.

Table 1 shows the frequency distribution of different confounding factors of maternal characteristics between exclusive and Non-EBF 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 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.

***Identifying Overdispersion***

In Poisson regression analysis, the mean number of diseases was 0.89 and the variance was 1.55. The variance was greater than the mean. Furthermore, the Goodness of fit parameters and Chi-square were 1.80 and 1.77, respectively. These mean-variance relations and goodness of fit statistics (larger than 1) indicate that data were over-dispersed and that the Poisson and ZIP models should be rejected in favor of the NB and ZINB models.

***Test of Excess Zeros***

By using the Vuong test statistics, we tested excess zeros for comparing the Poisson and NB regression models to the ZIP and ZINB regression models, respectively. The test statistics, V = 7.56, and the P-value was <0.001 for ZIP versus Poisson and V = 5.49, and the P-value was <0.001 for ZINB versus NB. The positive Vuong test statistics suggested that both ZIP and ZINB provided a better fit than their one-component counterparts according to overdispersion or access zero (table 3). The Vuong tests also rejected the ZIP models in favor of their overdispersion and excess zero, preferred the ZINB model (V= 4.15, P-value<0.001).

***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).

**Discussion:**

Based on the study, greater than five out of every ten newborns has exclusively breastfed, an approximately similar result was observed in a previous cross-sectional study was conducted in Popular Medical College, Dhanmondi, Dhaka, were found that the exclusive breastfeeding was exactly half of their sample (F. R. Chowdhury et al., 2018). This finding is comparable with studies done in Chittagong, Bangladesh (61.4%) (Mihrshahi et al., 2008), Pakistan (38%) (Noh et al., 2019), and India (56.0%) (Nishimura et al., 2018).

Once he/she was born, a symbolic procedure was done with the baby, and people strongly believe that only breast milk is not enough for growth without giving porridge. Common reasons for starting a supplemental diet were inadequate breast milk, and mothers' perceptions that the child was thirsty, given to women, were observed in different settings. The result of the bivariate analysis showed that exclusive breastfeeding practice was associated with division, age of child, and childhood diseases. In this study of mother-infant pairs from an urban region of Bangladesh, more than half of the mothers exclusively breastfed to their child, which is similar to the national rate of 55.0% represented by the global population (Yun et al., 2013). The variations persisting in the EBF rate in different regions worldwide might be due to cultural, economic, and socio-demographic differences across areas.

This study has shown that infants of Bangladesh who were not exclusively breastfed had a significantly higher chance of diseases than infants who were exclusively breastfed. After adjusting several confounders this effect was significant and remained high. In a recent study with data from India, Peru and Ghana showed that non-exclusive breastfed infants were substantially higher risk of getting diseases and dying compared with those who had been exclusively breastfed, with the most common causes being diarrhea, ARI (Bahl et al., 2005).

Infants with illiterate mothers will be more likely to get childhood diseases compared to mothers with higher educational attainment. This might happen as educated mothers understand and be better informed of the benefits of EBF thus delay the introduction of other feeds. This study clearly showed that mothers with higher levels of education were more likely to practice EBF compared to lower education levels. This was similar to a study conducted in Ibadan, southwestern Nigeria (Lawoyin et al., 2001). This study also observed that women in the poorest, poor, middle wealth status were more likely associated with childhood diseases than the richest. Infants who lived with the poorest mothers will more likely getting childhood diseases compared to mothers who lived in the richest family. This may be related to the knowledge of breastfeeding practices. This poorest mother is also more likely to engage for household work thereby hampering to some extent the preconditions for EBF practice. As a result, their infant has more likely to risk getting diseases. They may need better education on the ability of breastfeeding while they are at work or away. Poverty and rural women were cited EBF by many respondents. Many respondents in poverty and rural women identified as some of the impediments against EBF. Previous studies have shown that breastfeeding affects by wealth index or income of the household (Muchacha & Mtetwa, 2015).

The study has several strengths. The nationally representative data used in this study were collected from different levels of Bangladesh. This data set is collected through a reliable and uniform procedure, which provides an important source of information on infant feeding practices and infant diseases with minimizing the measurement error and bias. The response rates of this study were high.

One of the strengths of the present study is to remove this clustering effect in order to obtain the correct risk factors considering the effect of cluster variation. It is also ensuring that the standard errors of coefficients have been accurately estimated. We used Zero-inflated negative binomial regression for analyzing the data.

**Conclusions and Recommendations**

The best starter to an infant’s life is breastfeeding. It safeguards appropriate nutrition for the baby and ensures development. Profits of breastfeeding in terms of infant nutrition, immunity, and maternal welfare are emphasized in breastfeeding counseling. This study reveals that there is an association between EBF and children's healthy development. Common childhood infectious diseases can do rare harm in infants’ bodies because of EBF other than infants who are not-EBF. So, to ensure better health for 0-6-month infants there is no alternative of EBF. Children from six to 12 months of age veteran frequent episodes of child diseases and hospitalization than children under six months of age. EBF infant offered a lower prevalence of severe childhood diseases than the non-EBF. Mother's concentration, Family’s cooperation can play a vital role to create an atmosphere for EBF.

So, it is recommended that steps should be taken to improve the existing situation. It is so crucial that EBF has to be promoted a lot to reduce infant diseases. For this realization, the Federal Ministry of Health and Family Welfare of Bangladesh, local and international NGOs working on health areas, and health institutions should play their role to enhance exclusive breastfeeding practice of mothers with training during antenatal and postnatal visits for women. Health personnel who are working in the clinics should advise mothers to have a spontaneous vaginal delivery and should not insist on performing C-Section delivery unless and otherwise medically justified. It is high time to create a facility for breastfeeding in the workplace and to take steps for the uniform duration of maternity leave (6months) all over the country.

**Limitations**

BDHS is a nationally representative household survey of Bangladesh. However, the main limitation of this paper is to use a cross-sectional study and hence it may produce selection and information bias, and this study such as the information was derived from a secondary source. Due to financial and time constraints, the paper could not add primary data in supporting the BDHS data. The definition of EBF used here according to the 24 h-recall periods is subject to bias and misreporting. We are also aware of the risk of recall bias considering the nature of some questions which may not be recorded in any document. Although EBF was statistically significant, most other factors were not for childhood diseases. Reverse causation is a form of bias problems may be a threatens in the result of this study. For example, if mothers showed a tendency to exclusively breastfeed their babies because they were sick, the effect of exclusive breastfeeding on any illness would be underestimated. In contrast, if the mothers stop breastfeeding as a result of the illness, then this would have biased the results towards an overestimation of an effect.

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**Tables and figures**

**Child age between 0-5 months were included (n= 632)**

**Children age greater than six months were excluded (n=6868)**

**Total number of mother-child pairs in BDHS 2014 (n=7886)**

**Children were not living with their mother were excluded**

**(n= 1236)**

**Children live with their mother were included (n= 7500)**

**Figure 1: Data selection flow chart of the study population**

|  |
| --- |
|  |
| **Figure 2: Distribution of outcome variables** |

|  |
| --- |
|  |
| **Figure 3: Distribution of exposure variables** |

**Table 1: Chi-Square test for identifying maternal characteristics associate with exclusive breastfeeding among infant in Bangladesh**

|  |  |  |  |
| --- | --- | --- | --- |
| **Characteristics** | **EBF (%)** | **Non-EBF (%)** | **P-Value\*** |
| **Age** | | |  |
| 15-19 | 107 (28.53) | 91 (35.41) | 0.542 |
| 20-24 | 120 (32.00) | 73 (28.40) |  |
| 25+ | 148 (39.47) | 93 (36.19) |  |
| **Area of residence** | | | |
| Rural | 260 (69.33) | 168 (65.37) | 0.790 |
| Urban | 115 (30.67) | 89 (34.63) |  |
| **Geographical location** | | |  |
| Chittagong | 76 (20.27) | 50 (19.46) | <0.001 |
| Dhaka | 48 (12.80) | 56 (21.78) |  |
| Khulna | 47 (12.53) | 23 (8.96) |  |
| Rajshahi | 40 (10.67) | 31 (12.06) |  |
| Rangpur | 60 (16.00) | 16 (6.23) |  |
| Sylhet | 67 (17.86) | 29 (11.28) |  |
| Barisal | 37 (9.87) | 52 (20.23) |  |
| **Mother’s educational level** | | |  |
| No education | 49 (13.07) | 35 (13.62) | 0.955 |
| Primary | 93 (24.80) | 72 (28.02) |  |
| Secondary | 166 (44.26) | 110 (42.80) |  |
| Higher | 67 (17.87) | 40 (15.56) |  |
| **Mother’s employment status** | | |  |
| Yes | 59 (15.73) | 37 (14.40) | 0.535 |
| No | 316 (84.27) | 220 (85.60) |  |
| **Father’s Occupation** | | |  |
| Farmer | 46 (12.27) | 32 (12.60) | 0.389 |
| Agriculture Worker | 33 (8.80) | 18 (7.09) |  |
| Businessman | 80 (21.33) | 60 (23.62) |  |
| Others (Labor, Entrepreneur, Driver, etc.) | 216 (57.60) | 144 (56.69) |  |
| **Religion** | | |  |
| Islam | 342 (91.20) | 244 (94.94) | 0.438 |
| Others (Hinduism and Buddhism) | 33 (8.80) | 13 (5.06) |  |
| **Mass Media (at least once in a week)** | | |  |
| Yes | 237 (63.20) | 153 (59.53) | 0.923 |
| No | 138 (36.80) | 104 (40.47) |  |
| **Wealth Status** | | |  |
| Poorest | 67 (17.87) | 55 (53.88) | 0.060 |
| Poorer | 83 (22.13) | 47 (31.19) |  |
| Middle | 73 (19.47) | 48 (47.50) |  |
| Rich | 152 (40.53) | 107 (41.63) |  |
| **Mother’s BMI** | | |  |
| Over weight | 80 (21.39) | 50 (19.53) | 0.383 |
| Normal weight | 231 (61.76) | 148 (57.81) |  |
| Under weight | 63 (16.85) | 58 (22.66) |  |
| **Household members** | | |  |
| > 5 | 211 (56.27) | 144 (56.03) | 0.509 |
| ≤ 5 | 164 (43.73) | 113 (43.97) |  |

\*p-value obtained from chi-square test of contingency table

Data are in (weighted %). Absolute number of participants does not perfectly correspond to percentages presented because weighted analyses were used.

**Table 2: Chi-Square test for identifying child’s characteristics associate with exclusive breastfeeding among infant in Bangladesh**

|  |  |  |  |
| --- | --- | --- | --- |
| **Characteristics** | **EBF (%)** | **Non-EBF (%)** | **P-Value\*** |
| **C-section** | | |  |
| Yes | 102 (27.20) | 76 (29.57) | 0.934 |
| No | 273 (72.80) | 181 (70.43) |  |
| **Sex of child** | | |  |
| Male | 201 (53.60) | 141 (54.86) | 0.925 |
| Female | 174 (46.40) | 116 (45.14) |  |
| **Size of child at birth** | | |  |
| Small | 72 (19.20) | 58 (22.57) | 0.615 |
| Average | 260 (69.33) | 170 (66.15) |  |
| Large | 43 (11.47) | 29 (11.28) |  |
| **Age of child (in months)** | | |  |
| 4-5 | 83 (22.13) | 147 (57.20) | 0.000 |
| 2-3 | 144 (38.40) | 79 (30.74) |  |
| 0-1 | 148 (39.47) | 31 (12.06) |  |

\*p-value obtained from chi-square test of contingency table

Data are in (weighted %).

Absolute number of participants does not perfectly correspond to percentages presented because weighted analyses were used.

**Table 3: Model comparison and access zero test by Vuong tests.**

|  |  |  |  |
| --- | --- | --- | --- |
| **Model Composition** | **Test Performed** | **P-value** | **Preferred Model** |
| ZIP vs PR | 7.56 | <0.001 | ZIP |
| ZINB vs NB | 5.49 | <0.001 | ZINB |
| **ZINB vs ZIP** | **4.15** | **<0.001** | **ZINB** |

**Table 4: Goodness of fit statistics (Log-likelihood, AIC, AICc and BIC) for the PR, NB, ZIP and ZINB models.**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Model** | **Log-likelihood** | **AIC** | **AICc** | **BIC** |
| PR | -632.04 | 1870.50 | 1870.52 | 1879.40 |
| NB | -558.16 | 1659.14 | 1659.17 | 1672.48 |
| ZIP | -539.18 | 1686.79 | 1686.82 | 1700.13 |
| **ZINB** | **-795.08** | **1598.15** | **1598.22** | **1615.95** |

**Table 5: Influence of EBF on the early childhood diseases**

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Zero-inflated Negative Binomial Regression** | | |
|  | **CRR** | **95% CI** | **P-value** |
| **EBF** | | | |
| No | 1.24 | [1.01,1.57] | 0.045 |
| Yes | Ref. | - | - |

**Table 6: Association between EBF and childhood diseases 0-6 months aged children in Bangladesh when possible confounding variables adjusted to the models**

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Zero-inflated Negative Binomial Regression** | | |
|  | **ARR** | **95% CI** | **P-value** |
| **EBF** | | | |
| No | 1.27 | [1.01,1.60] | 0.033 |
| Yes | Ref. | - | - |
| **Maternal age** | | | |
| 15-19 | 1.10 | [0.85,1.42] | 0.465 |
| 20-24 | 0.95 | [0.73,1.22] | 0.667 |
| 25+ | Ref. | - | - |
| **Area of residence** | | | |
| Rural | 0.98 | [0.77,1.25] | 0.873 |
| Urban | Ref. | - | - |
| **Geographical location** | | | |
| Chittagong | 1.73 | [1.17,2.56] | 0.006 |
| Dhaka | 1.38 | [0.91,2.07] | 0.126 |
| Khulna | 1.23 | [0.78,1.94] | 0.372 |
| Rajshahi | 1.19 | [0.75,1.91] | 0.456 |
| Rangpur | 1.39 | [0.90,2.16] | 0.138 |
| Sylhet | 1.74 | [1.23,2.71] | 0.013 |
| Barisal | Ref. | - | - |
| **Mother’s educational level** | | | |
| No education | 1.47 | [0.95,2.31] | 0.087 |
| Primary | 1.41 | [0.95,2.09] | 0.087 |
| Secondary | 1.34 | [0.94,1.89] | 0.103 |
| Higher | Ref. | - | - |
| **Mother’s employment status** | | | |
| Yes | 1.03 | [0.77,1.39] | 0.831 |
| No | Ref. | - | - |
| **Fathers’ occupation** | | | |
| Farmer | 1.01 | [0.72,1.42] | 0.946 |
| Agriculture Worker | 0.88 | [0.59,1.31] | 0.526 |
| Businessman | 0.81 | [0.62,1.07] | 0.140 |
| Others (Labor, Driver, Entrepreneur, etc.) | Ref. | - | - |
| **Religion** | | | |
| Islam | 1.41 | [0.91-2.19] | 0.129 |
| Others (Hinduism and Buddhism) | Ref. | - |  |
| **Mass media (at least once in a week)** | | | |
| No | 1.30 | [0.99,1.70] | 0.056 |
| Yes | Ref. | - | - |
| **Wealth status** | | | |
| Poorest | 1.48 | [1.02,2.17] | 0.040 |
| Poorer | 1.35 | [0.96,1.89] | 0.082 |
| Middle | 1.34 | [0.99,1.83] | 0.060 |
| Rich | Ref. | - | - |
| **Mother’s BMI** | | | |
| Over weight | 1.53 | [1.16,2.01] | 0.002 |
| Under weight | 1.07 | [0.74,1.55] | 0.702 |
| Normal weight | Ref. | - |  |
| **Household members** | | | |
| > 5 | 1.06 | [0.86,1.31] | 0.576 |
| ≤ 5 | Ref. | - |  |
| **C-section** | | | |
| Yes | 1.04 | [0.81,1.33] | 0.780 |
| No | Ref. | - |  |
| **Sex of child** | | | |
| Male | 1.11 | [0.90,1.36] | 0.340 |
| Female | Ref. | - |  |
| **Size of child at birth** | | | |
| Small | 1.17 | [0.79,1.71] | 0.434 |
| Average | 1.10 | [0.80,1.52] | 0.552 |
| Large | Ref. | - | - |
| **Age of child (months)** | | | |
| 4-5 | 1.99 | [1.44,2.75] | <0.001 |
| 2-3 | 1.69 | [1.22,2.39] | 0.002 |
| 0-1 | Ref. | - |  |

**Supporting information**

**S1 Table: Unadjusted LR statistics for type 3 analysis**

|  |  |  |
| --- | --- | --- |
|  | **Zero-inflated Negative Binomial Regression** | |
| **Source** | **Chi-Square** | **P-value** |
| **EBF** | 5.45 | 0.020 |

**S2 Table: Adjusted LR Statistics for Type 3 Analysis**

|  |  |  |
| --- | --- | --- |
|  | **Zero-inflated Negative Binomial Regression** | |
| **Covariates** | **Chi-Square** | **P-value** |
| **EBF** | 4.58 | 0.032 |
| **Mother’s Age** | 1.46 | 0.482 |
| **Residence** | 0.02 | 0.902 |
| **Geographical location** | 10.38 | 0.110 |
| **Mother’s educational level** | 3.67 | 0.299 |
| **Mother’s employment status** | 0.05 | 0.824 |
| **Fathers’ Occupation** | 2.60 | 0.458 |
| **Religion** | 2.40 | 0.121 |
| **Mass media (at least once in a week)** | 3.56 | 0.060 |
| **Wealth Status** | 5.47 | 0.140 |
| **Mother’s BMI** | 13.31 | <0.001 |
| **Household members** | 0.31 | 0.575 |
| **C-Section** | 0.08 | 0.772 |
| **Sex of child** | 0.88 | 0.347 |
| **Size of child at birth** | 0.61 | 0.737 |
| **Age of child (months)** | 16.97 | <0.001 |