**Assessing Contributory Factors of Diarrhea among Under-Five Children in Bangladesh: A Comprehensive Analysis of Three Waves of Nationally Represent Data**

**Abstract**

**Aim:**

Diarrhea remains a significant cause of child mortality in Bangladesh. One-third of all child deaths in this country are caused by diarrhea. This study aimed to investigate the changing patterns and contributory factors of diarrheal diseases among children 0-5 years by analyzing three distinct survey years.

**Methods:**

In this study, using the data from the Multiple Indicator Cluster Survey (MICS), a total of 31,566, 23,402, and 24,686 children under five were included from, 2006, 2012, and 2019, respectively. Logistic regressions were applied to analyze the factors influencing childhood diarrhea.

**Results:**

The results revealed a decline in diarrhea prevalence from MICS 2006 (7.1%) to MICS 2012 (3.9%). However, there was an unfortunate increase to 6.9% in MICS 2019. Notably, children aged 12-23 months exhibited consistently 2.22 (adjusted odds ratio (AOR) = 2.22, 95% confidence interval (CI: 1.86 – 2.65), 5.24 (CI: 2.51 – 10.95) and 3.36 (CI: 2.67 – 4.22) times higher likelihood of experiencing diarrhea compared to the older age group (48-59 months) in MICS 2006, 2012 and 2019, respectively. Children whose mothers had no or incomplete primary education had higher chances of diarrhea compared to children of mothers with secondary complete or higher education.

**Conclusion:**

Furthermore, underweight status, geographical division, household wealth status, and toilet facility type and its shared status emerged as contributing factors of diarrhea among children aged 0-5 years. The findings underscore the importance of child nutrition, basic hygiene practices, and special care to mitigate the under-five mortality rate associated with diarrhea.

**Keywords:** Children, Nutrition, Childhood diseases, Diarrhea, Trend, Determinant

**Introduction**

Diarrhea is an influential cause of under-five child mortality globally. In 2010, about 7.6 million Children aged below five years died worldwide and about 21,000 of them died every day (Woldu et al. 2016). According to the World Health Organization (WHO) and the United Nations Children’s Fund (UNICEF), Diarrheal diseases account for approximately 18% death of children aged under 5 years worldwide; more than 5000 children are dying every day and among them, 78% of all child death from diarrhea occur in the African and South-East Asian regions (Farthing et al. 2013). Each year in developing countries, almost 2 million people die of diarrhea, a significant number of whom are children aged between 0-5 years (Tilahun et al. 2014). Due to high mortality rates in developing countries, the loss of human lives is the main concern for those countries while the developed countries focus on reducing the economic cost associated with the cases of diarrhea (Pinzón-Rondón et al. 2015).

Among the South Asian countries, the percentage of deaths due to diarrhea among children under five was high for Pakistan (8%), followed by India (7%) and Bangladesh (7%), and low for Maldives (1%) and Sri Lanka (1%) in 2019. In a developing country like Bangladesh, most children suffer from diarrheal diseases which ultimately lead them to death (Shah et al. 2003). Each year, in Bangladesh, every child suffers three to five times the average from diarrheal attacks (Alam 2007). A previous study showed that diarrhea is the reason behind about 33% of total child deaths in Bangladesh. According to the 2007 Bangladesh Demographic and Health Survey (BDHS) data, most sufferers are 6-23 months old children and boys are more at risk of this disease compared to girls (Sharifa Begum 2011).

Young children in Bangladesh generally experience a variety of common illnesses like fever, cough, short/difficult breathing, diarrhea, etc. (Hasan et al. 2020; Islam et al. 2022). Previous studies on diarrhea found several risk factors which were rainy season, partial breastfeeding and early weaning, lower education level of mother, outdoor drinking water source like river, outdoor faucet, distance of drinking water source, unprotected water storage container, not treating drinking water, larger household size, lower household income, having dirt/wood/bark as floor material, not having antenatal care during pregnancy, unimproved sanitation system, wastewater to septic tank/street, disposal of child faces indiscriminately, no hand washing facility, and unhealthy home environment (garbage and flies near home) (Sobel et al. 2004; Genser et al. 2006; Kosek et al. 2008; Tornheim et al. 2009; Strand et al. 2012; Maponga et al. 2013; Getachew et al. 2018; Shine et al. 2020). It was identified that boys and younger children had a higher risk of having diarrhea (Sobel et al. 2004; Genser et al. 2006; Strand et al. 2012; Getachew et al. 2018; Shine et al. 2020). To reduce child morbidity and mortality, the prevention of diarrhea is indispensable.

According to the information that we have, no study was conducted using the Multiple Indicator Cluster Survey (MICS) data of Bangladesh to portray the changes in factors influencing diarrhea over time. We intended to investigate the relationship between diarrhea and important features such as drinking water source, health of children, household economic status, and household environment. Additionally, we aimed to analyze the evaluation of diarrhea prevalence and identify the factors contributing to diarrheal diseases among children aged 0-5 years in Bangladesh between 2006 and 2019.

**Methods**

We followed the STROBE guideline for better observational cross-sectional study reporting in epidemiology (Table S1).

**Study design**

We used secondary data from the years 2006, 2012-13, and 2019 of MICS of Bangladesh. Bangladesh MICS is a part of the global MICS program, Bangladesh Bureau of Statistics (BBS), and worked with the United Nations Children’s Forum (UNICEF) which supported this survey by providing technical and financial support. This survey report has circumstantial information and investigation on children and women of Bangladesh for disease, health condition, household facilities, educational status, knowledge and practices related to disease prevention, access to media and technology, which is named *“Progotir Pathey”* (UNICEF 2023).

The sampling procedure was a two-stage stratified cluster sampling covering urban and rural areas of Bangladesh where enumeration areas (EAs) were selected at the first stage and households with each selected EAs were selected at the second stage. In the survey of 2006, 2012-13, and 2019, a total of 31,566, 23,402, and 24,686 children under age 5 completed the questionnaire among 34,710, 20,903, and 23,099 children identified from interviewed households with a response rate of 90.9, 89.3, and 93.6 percent, respectively [**Figure 1**]. The sample size estimation and sample allocation are available in detail in the final reports of each survey (UNICEF 2023).

**Outcome and possible covariates**

**Outcome variable**

Diarrhea is determined by whether 0-5-year-old children had diarrhea in the past two weeks or not and the answer is given by mothers or caretakers of children. Here, the Diarrhea variable has two categories: “Yes” for having diarrhea and “No” for not having diarrhea.

**Covariates**

Characteristics of children such as age, sex, child supervision, nutritional status (stunned, wasted, underweight, overweight), community characteristics e.g. place of residence, division, parental characteristics e.g. mother’s education and age, household characteristics e.g. wealth index, religion, sex of household head, type of toilet facility and its shared status, salt iodization, access to mass media, household size, possession of livestock, drinking water source and type, water treatment were considered as covariates in the analysis. The covariates were selected for the analysis based on the available information in MICS dataset and the findings of previous studies (Shah et al. 2003; Genser et al. 2006; Siziya et al. 2009; Strand et al. 2012; Ferdous et al. 2013; Maponga et al. 2013; Sinmegn Mihrete et al. 2014; Tambe et al. 2015; Bado et al. 2016; Woldu et al. 2016; Das et al. 2019; Melese et al. 2019; Rahman and Hossain 2022).

A child had inadequate supervision if the child was not with any adult for more than one hour at least once during the last week. Stunting, wasting, underweight, and overweight were used as the measurements of nutritional status, and height-for-age, weight-for-age, and weight-for-height z-scores were used to calculate these measures (WHO 2023). The z-scores measure the distance of a measurement from its mean point in terms of standard deviation. A child was considered underweight if the weight for age z-score was less than or equal to -2 and overweight if the weight for height z-score was greater than or equal to 2. A child was stunned if the height for age z-score was less than or equal to -2 and wasted if the weight for height z-score was less than or equal to -2 (WHO 2023).

Flushed to the piped sewer system, septic tank, pit latrine, and open drain, ventilated improved pit latrine, pit latrine with and without slab were categorized as improved toilet facility and hanging toilet/latrine, bucket, composite toilet, and no facility/bush/field were categorized as unimproved toilet facility (UNICEF 2023). Salt iodization was considered “Yes” if the salt tested result showed 0 to 15 ppm or above 15 ppm and otherwise “No”. Having access to mass media indicated that a household at least accessed magazines/newspapers/TV/radio less than once a week. Piped into dwelling, to yard and neighbor, public tap, tube well, dug well (protected), protected spring, rainwater, bottled and sachet water were considered as an improved water source and dug well (unprotected), unprotected spring, tanker truck, cart with a small tank, water selling plant, surface water (river, dam, lake, pond, canal) and other were considered as an unimproved water source (UNICEF 2023).

**Data analysis**

Stata Statistical software for data science version 17.0 was used for data analysis. We applied univariate and multivariable logistic regressions to assess the association between diarrhea and the selected covariates at a 5% significance level for each dataset. The final model output was represented in a forest plot.

The procedure for choosing the best model was step-wise logistic regression. In addition, the measures of sensitivity and specificity from the Receiver Operating Characteristic (ROC) curve, were used to assess the optimal model. A bigger area under the curve than 0.50 on the ROC curve indicates that the model discriminates between the two groups (Cook and Rajbhandari 2018). We also employ information criteria, e.g., the Akaike information criterion (AIC (Akaike 1974)) and Bayesian information criterion (BIC (G 1978)) as a goodness-of-fit measure for the final multivariable logistic model.

We used the Stata command (Svyset) of the survey data reference manual to account for the complex survey settings of the datasets (Stata 2023). Svyset commands were developed for STATA to consider the survey design elements such as sample weights, PSU, clusters, and strata (UCLA 2023).

**Results**

The occurrence of diarrhea among 0-5-year-old children decreased from 7.1% in 2006 to 3.9% in 2012 then increased to 6.9% in 2019.  Moreover, among the age group 12–23-month children 10.0%, 7.7%, and 10.1% had diarrhea respectively based on the MICS data of 2006, 2012, and 2019. Based on the division in Barisal 8.9%, 6.3%, and 14.1% of children had diarrhea respectively as reported highest in 2006, 2012, and 2019 MICS data. Likewise, the MICS data from 2006, 2012, and 2019 reported that in the Khulna division 4.4%, 3.3%, and 6.5% of under-five children had the lowest diarrhea respectively. In 2012, it was lowest in over 35 years age group, 3.2%. According to the wealth index, among under-age five children who belonged ​to rich families 5.6% of them had the lowest diarrhea in the survey time of 2006, in contrast, it was the lowest 3.4% in middle and 5.5% in richest families in 2012 and 2019, respectively. Among the children under 5 years whose families didn’t consume adequately iodized salt 8.6% of them had the highest prevalence of diarrhea in 2006 which decreased to 8.0% in 2019, but the lowest was in 2012, 3.8% (Table 1).

From the univariate model, we have found that the age of the child, underweight, area of the household, division, education level of mother, mother’s age, wealth status, religion, ethnicity, toilet facilities shared, toilet facility type, salt iodization variables were significantly associated with diarrhea at 5% level of significance (Table S2).

According to multivariate model, we found that the children of 0-11 months had 1.81 (adjusted odds ratio (AOR): 1.81, 95% CI: 1.50-2.18), 4.35 (AOR: 4.35, 95% CI: 2.10-9.01), and 3.32 (AOR: 3.32, 95% CI: 2.63-4.19) times higher odds of having diarrhea compared with children aged 48-59 months in 2006, 2012 and 2019 respectively. Compared with the children under age 5 from the Sylhet division in the 2006, 2012, and 2019 surveys, children of the Barisal division had 1.27 (AOR: 1.27, 95% CI: 0.99-1.63) and 2.51 (AOR: 2.51, 95% CI: 1.74-3.63) times higher chance of having diarrhea, respectively. However, in a 2012 survey, children of the Barisal division had a 33% (AOR: 0.67, 95% CI: 0.27-1.63) times lower chance of having diarrhea. Children from the poorest family had 30% (MICS 2006 AOR: 1.30, 95% CI:1.01-1.65) and 14% (MICS 2019 AOR: 1.14, 95% CI: 0.90-1.44) higher odds of having diarrhea compared with children from the richest family. We found that among the children whose families use the shared toilet had 7% (AOR: 1.07, 95% CI: 0.96-1.20) and 23% (AOR: 1.23, 95% CI: 1.07-1.42) higher odds of having diarrhea in 2006 and 2019 respectively, in MICS 2012, 40% (AOR: 0.60, 95% CI: 0.36-0.99) lower odds of having diarrhea in compared with the children whose family did not use the shared toilet (Table 2 and Figure 2).

The area under the ROC curve was found to be 0.6210 (P < 0.001), 0.6826 (P < 0.001), and 0.6717 (P < 0.001). This indicated that the final model chosen for the MICS-2006, MICS-2012, and MICS-2019 surveys each displayed an area under the curve that was higher than 0.50 (Figure 3). The improved goodness-of-fit statistics for the final multivariate logistic model lend credence to this inference. In comparison to the MICS-2006 (AIC = 14322.83, BIC = 14545.55) and MICS-2019 (AIC = 9610.21, BIC = 9870.85) final multivariate logistic model, MICS-2012 demonstrated (AIC = 1167.66, BIC = 1295.21). The MICS-2012 survey model therefore provided a good fit, and a normal binary logistic model with variables included in this survey model was suggested to use to describe this type of analysis (Table 3).

**Discussion**

This study targeted to explore the MICS data of 2006, 2012, and 2019 and assess the association of several factors with diarrhea and the change of it over time. There was a decrease in the prevalence of diarrhea from 2006 to 2012 and an increase in 2019 among 0-5-year-old children in Bangladesh.

The prevalence was higher for 12-23 months children, followed by 0-11 months children, and the difference is significant compared with children of 48-59 months age group in 2006, 2012, and 2019. Children of the 0-24 months age group are in the process of developing immune systems and depend on their mothers to be protected (Siziya et al. 2009). Also, children from 6 to 24 months start crawling all over the house and put whatever they find around them in their month. As they gradually grow up, they learn what is not to eat or put in their mouths (Negesse et al. 2021).

Findings showed that the chance of having diarrhea was significantly higher for children from the poorest families in 2006 and children from the second wealth index in 2019. Children from poor families have more probability of being affected by several childhood illnesses due to poor living conditions, not having enough nutritious food, and poor condition of drinking water sources and toilet facilities (Guerrant et al. 2013; Iannotti et al. 2015; Rahman and Hossain 2022).

Children from households without improved toilet facilities in 2006 and 2019 were more at risk of experiencing diarrhea. Using the composite toilet, bucket, hanging toilet/latrine, and going to bush/field causes the unsafe disposal of stools in the neighborhood, which is connected to the chance of having diarrhea among children (Bawankule et al. 2017). Accessing improved toilet facilities can reduce the unsafe disposal of stools and the transmission of the virus from one human to another, which ultimately reduces the prevalence of diarrhea, supported by the findings from Ethiopia, Ghana, and India (Fobil et al. 2011; Mengistie et al. 2013; Sinmegn Mihrete et al. 2014; Michael Geruso et al. 2018).

After controlling the effects of several factors, we found that no factors were influencing the prevalence of diarrhea in 2012 but children from households that used shared toilet facilities had a lower chance of diarrhea in 2012. However, it is not sure that the shared toilet facility caused diarrhea, but the unhygienic toilet facility contains pathogens like norovirus, which caused diarrhea (Just et al. 2018).

In 2006, Children from Khulna had a significantly lower chance of diarrhea than Children from Sylhet. Compared with Sylhet, children from Barisal were significantly more at risk, but children from Rangpur were less at risk of having diarrhea in 2019. Water-borne diseases like diarrhea are more observed in water-prone areas like the northeastern and southern parts of Bangladesh (Das et al. 2019). Sylhet division always faces sudden floods during the rainy season, and the water gets stuck in several areas of Sylhet for a long time, providing a favorable state to increase the infection of diarrhea among people. Moreover, some districts of the Khulna, Barisal, and Chittagong divisions are part of the southern coastal region with salty water (Islam et al. 2019). The chance of having diarrhea was higher for children from these places than in other parts of Bangladesh.

**Strengths and limitations**

The findings of this study represent the scenario of under-five children at the time of the survey years. Several variables were assessed during analysis which has chances of influencing diarrhea. Despite these benefits, there were a few flaws with our research. There was no control over the definition of variables and their measurement scales and criteria. Additionally, the survey was conducted in 2006, 2012, and 2019. Therefore, the diarrheal status may have changed since the survey's midpoint or at that time. In addition, information about children's food habits also needed to be given. Furthermore, the cross-sectional data only provide the power to analyze the association of the factors with the outcome variables.

**Recommendations**

Governments, international organizations, non-governmental organizations, and public health professionals should consider the results of this study when making decisions about how to improve child health over time and stop diarrhea in Bangladesh. Hopefully, this study will help policymakers to focus on interventions that are feasible and can be implemented to reduce the risk. Beyond the usual development standards, expanding nutrition and direct diarrhea interventions, water, sanitation, and hygiene (WASH), and basic sanitation practices like handwashing with soap can reduce the rate of childhood diarrhea. Additionally, efforts should be reassessed and stepped up to improve sanitary infrastructure, personal and food hygiene, and home waste management.

**Conclusion**

Our study shows that factors such as the age of the child, underweight, division, wealth status, religion, shared toilet facilities, and toilet facility type significantly influenced the chance of having diarrhea among 0-5-year-old children in Bangladesh. Younger children, primarily those between the ages of 12 and 23 months, underweight children, children from the poorest households, and households with inadequate sanitation facilities had a higher chance of having diarrhea. Private and improved toilet facilities, hygiene practices, and proper nutrition for children can reduce childhood diarrhea.

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**Tables and Figures**

**Table 1 Distribution of several factors with the diarrhea status of children, MICS 2006, 2012, and 2019.**

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Characteristics | 2006 | | | 2012 | | | 2019 | | |
| Diarrhea | | P-value | Diarrhea | | P-value | Diarrhea | | P-value |
| Yes | No |  | Yes | No | Yes | No |
| N (%) | N (%) |  | N (%) | N (%) | N (%) | N (%) |
| CHILD CHARACTERISTICS | | | | | | | | | |
| Age of child (in months) | | | | | | | | | |
| 0-11 | 483 (8.5) | 5185 (91.5) | **<0.001** | 213 (5.4) | 3769 (94.6) | **<0.001** | 421 (9.1) | 4184 (90.9) | **<0.001** |
| 12-23 | 606 (10.0) | 5423 (90.0) | 315 (7.7) | 3776 (92.3) | 448 (10.1) | 3986 (89.9) |
| 24-35 | 444 (7.0) | 5876 (93.0) | 140 (3.3) | 4048 (96.7) | 326 (7.1) | 4279 (92.9) |
| 36-47 | 388 (5.7) | 6398 (94.3) | 97 (2.2) | 4232 (97.8) | 247 (5.1) | 4570 (94.9) |
| 48-59 | 332 (4.9) | 6410 (95.1) | 61 (1.4) | 4242 (98.6) | 154 (3.3) | 4473 (96.7) |
| Child’s sex | | | | | | | | | |
| Male | 1200 (7.4) | 15017 (92.6) | 0.107 | 421 (3.9) | 10268 (96.1) | 0.931 | 860 (7.2) | 11144 (92.8) | 0.178 |
| Female | 1054 (6.9) | 14278 (93.1) | 404 (4.0) | 9799 (96.0) | 736 (6.6) | 10347 (93.4) |
| Inadequate Supervision | | | | | | | | | |
| Yes | - | - |  | 82 (5.1) | 1504 (94.9) | 0.057 | 120 (8.1) | 1367 (91.9) | 0.079 |
| No | - | - | 742 (3.8) | 18545 (96.2) | 1477 (6.8) | 20122 (93.2) |
| Underweight | | | | | | | | | |
| Yes | - | - |  | 259 (4.0) | 6167 (96.0) | 0.879 | 439 (8.5) | 4698 (91.5) | **<0.001** |
| No | - | - | 537 (4.0) | 12950 (96.0) | 1120 (6.5) | 16181 (93.5) |
| Stunned | | | | | | | | | |
| Yes | - | - |  | 323 (3.9) | 7893 (96.1) | 0.867 | 461 (7.4) | 5765 (92.6) | 0.132 |
| No | - | - | 447 (4.0) | 10752 (96.0) | 1071 (6.8) | 14747 (93.2) |
| Wasted | | | | | | | | | |
| Yes | - | - |  | 92 (4.7) | 1862 (95.3) | 0.148 | 178 (8.1) | 2028 (91.9) | 0.053 |
| No | - | - | 699 (4.0) | 16979 (96.0) | 1353 (6.8) | 18442 (93.2) |
| Overweight | | | | | | | | | |
| Yes | - | - |  | 44 (2.8) | 1529 (97.2) | 0.050 | 90 (5.5) | 1539 (94.5) | 0.057 |
| No | - | - | 781 (4.0) | 18538 (96.0) | 1507 (7.0) | 19952 (93.0) |
| COMMUNITY CHARACTERISTICS | | | | | | | | | |
| Place of residence | | | | | | | | | |
| Urban | 1630 (7.1) | 21394 (92.9) | 0.293 | 627 (3.8) | 15998 (96.2) | 0.098 | 1255 (6.9) | 16932 (93.1) | 0.896 |
| Rural | 611 (7.4) | 7661 (92.6) | 198 (4.6) | 4069 (95.4) | 342 (7.0) | 4560 (93.0) |
| Tribal | 13 (5.1) | 240 (94.9) | - | - | - | - |
| Division | | | | | | | | | |
| Barishal | 167 (8.9) | 1705 (91.1) | **<0.001** | 80 (6.3) | 1188 (93.7) | **0.002** | 185 (14.1) | 1129 (85.9) | **<0.001** |
| Chattogram | 515 (7.6) | 6279 (92.4) | 218 (4.6) | 4571 (95.4) | 380 (7.6) | 4651 (92.4) |
| Dhaka | 704 (7.1) | 9228 (92.9) | 224 (3.5) | 6231 (96.5) | 311 (5.7) | 5177 (94.3) |
| Khulna | 139 (4.4) | 3008 (95.6) | 67 (3.3) | 1942 (96.7) | 155 (6.5) | 2238 (93.5) |
| Mymensingh | - | - | - | - | 153 (8.7) | 1597 (91.3) |
| Rajshahi | 540 (7.4) | 6743 (92.6) | 85 (3.6) | 2319 (96.4) | 182 (6.6) | 2568 (93.4) |
| Rangpur | - | - | 90 (3.8) | 2282 (96.2) | 112 (4.5) | 2379 (95.5) |
| Sylhet | 189 (7.5) | 2333 (92.5) | 61 (3.8) | 1533 (96.2) | 119 (6.3) | 1753 (93.7) |
| PARENTAL CHARACTERISTICS | | | | | | | | | |
| Mother’s Education | | | | | | | | | |
| Primary incomplete | 1299 (8.0) | 14912 (92.0) | **<0.001** | 319 (4.2) | 7323 (95.8) | 0.786 | 199 (7.7) | 2387 (92.3) | 0.052 |
| Primary complete | 274 (6.7) | 3808 (93.3) | 118 (3.6) | 3137 (96.4) | 402 (7.3) | 5078 (92.7) |
| Secondary incomplete | 489 (6.2) | 7454 (93.8) | 282 (3.9) | 7003 (96.1) | 779 (6.9) | 10548 (93.1) |
| Secondary complete or higher | 178 (5.5) | 3027 (94.5) | 106 (3.9) | 2605 (96.1) | 217 (5.9) | 3478 (94.1) |
| Non-standard curriculum | 14 (13.6) | 92 (86.4) | - | - | - | - |  |
| Mother’s Age at the Survey Time | | | | | | | | | |
| 15 – 19 | 471 (7.8) | 5605 (92.3) | 0.390 | 71 (5.4) | 1251 (94.6) | **0.004** | 294 (6.9) | 3944 (93.1) | 0.991 |
| 20-34 | 938 (7.1) | 12322 (92.9) | 578 (4.5) | 12410 (95.5) | 715 (6.9) | 9620 (93.1) |
| 35+ | 620 (7.2) | 7947 (92.8) | 112 (3.2) | 3440 (96.8) | 475 (7.0) | 6334 (93.0) |
| HOUSEHOLD CHARACTERISTICS | | | | | | | | | |
| Wealth Index | | | | | | | | | |
| Poorest | 685 (8.6) | 7299 (91.4) | **<0.001** | 246 (4.8) | 4857 (95.2) | 0.071 | 421 (8.4) | 4615 (91.6) | **<0.001** |
| Poor | 502 (7.6) | 6107 (92.4) | 155 (3.6) | 4128 (96.4) | 371 (8.2) | 4159 (91.8) |
| Middle | 420 (7.1) | 5495 (92.9) | 130 (3.4) | 3752 (96.6) | 262 (6.1) | 4036 (93.9) |
| Rich | 326 (5.6) | 5526 (94.4) | 139 (3.7) | 3609 (96.3) | 281 (6.2) | 4226 (93.8) |
| Richest | 321 (6.2) | 4867 (93.8) | 155 (4.0) | 3722 (96.0) | 262 (5.5) | 4456 (94.5) |
| Religion | | | | | | | | | |
| Islam | 2082 (7.3) | 26611 (92.7) | 0.061 | 710 (4.0) | 17115 (96.0) | 0.904 | 1489 (7.0) | 19658 (93.0) | **0.026** |
| Others | 172 (6.0) | 2684 (94.0) | 80 (3.9) | 1956 (96.1) | 107 (5.5) | 1834 (94.5) |
| Household Head Sex | | | | | | | | | |
| Male | 2155 (7.2) | 27838 (92.8) | 0.285 | 689 (4.0) | 16519 (96.0) | 0.704 | 1483 (7.0) | 19626 (93.0) | 0.067 |
| Female | 99 (6.3) | 1456 (93.7) | 101 (3.8) | 2552 (96.2) | 114 (5.7) | 1865 (94.0) |
| Ethnicity | | | | | | | | | |
| Bengali | 2225 (7.2) | 28813 (92.8) | 0.144 | 768 (4.0) | 18505 (96.0) | 0.814 | 1571 (6.9) | 21263 (93.1) | **0.019** |
| Other | 29 (5.7) | 476 (94.3) | 22 (3.7) | 567 (96.3) | 25 (10.0) | 229 (90.0) |
| Toilet facilities shared | | | | | | | | | |
| Yes | 943 (7.5) | 11636 (92.5) | **0.016** | 175 (3.4) | 4942 (96.6) | **0.038** | 541 (7.8) | 6365 (92.2) | **0.001** |
| No | 1076 (6.6) | 15123 (93.4) | 603 (4.2) | 13815 (95.8) | 1027 (6.5) | 14781 (93.5) |
| Toilet facility type | | | | | | | | | |
| Improved | 1436 (6.5) | 20646 (93.5) | **<0.001** | 758 (4.0) | 18343 (96.0) | 0.868 | 1491 (6.8) | 20531 (93.2) | **0.001** |
| Non-improved | 814 (8.7) | 8597 (91.4) | 31 (4.1) | 729 (95.9) | 104 (9.8) | 958 (90.2) |
| Salt Iodization | | | | | | | | | |
| Yes | 1803 (6.9) | 24430 (93.1) | **<0.001** | 591 (4.0) | 14067 (96.0) | 0.601 | 1141 (6.6) | 16239 (93.4) | **0.002** |
| No | 449 (8.6) | 4793 (91.4) | 199 (3.8) | 5002 (96.2) | 455 (8.0) | 5244 (92.0) |
| Mass Media | | | | | | | | | |
| Yes | - | - | - | 398 (4.3) | 8845 (95.7) | 0.817 | 851 (6.6) | 11968 (93.4) | 0.059 |
| No | - | - | 363 (4.2) | 8250 (95.8) | 634 (7.4) | 7930 (92.6) |
| Household size | | | | | | | | | |
| <5 | 718 (6.9) | 9708 (93.1) | 0.322 | 426 (3.8) | 10960 (96.3) | 0.154 | 925 (6.7) | 12865 (93.3) | 0.191 |
| 5/5+ | 1536 (7.3) | 19587 (92.7) | 363 (4.3) | 8111 (95.7) | 671 (7.2) | 8626 (92.8) |
| Livestock ownership | | | | | | | | | |
| Yes | - | - | - | 452 (4.0) | 10773 (96.0) | 0.786 | 913 (6.9) | 12329 (93.1) | 0.858 |
| No | - | - | 336 (3.9) | 8234 (96.1) | 682 (6.9) | 9116 (93.1) |
| Source water type | | | | | | | | | |
| Improved | 2216 (7.1) | 28783 (92.9) | 0.854 | 772 (4.0) | 18590 (96.0) | 0.687 | 1566 (6.90) | 21122 (93.10) | 0.537 |
| Unimproved | 38 (6.9) | 508 (93.1) | 17 (3.5) | 481 (96.5) | 30 (7.54) | 370 (92.50) |
| Source of water | | | | | | | | | |
| Direct from source | - | - | - | 8 (3.7) | 218 (96.3) | 0.097 | 27 (8.7) | 290 (91.4) | 0.366 |
| Covered container | - | - | 113 (4.2) | 2570 (95.8) | 216 (7.4) | 2706 (92.6) |
| Uncovered container | - | - | 32 (2.7) | 1166 (97.3) | 88 (6.3) | 1304 (93.7) |
| Water treatment | | | | | | | | | |
| Yes | 170 (8.1) | 1917 (91.9) | 0.214 | 88 (4.6) | 1828 (95.4) | 0.256 | 168 (6.9) | 2271 (93.1) | 0.945 |
| No | 2078 (7.1) | 27344 (92.9) | 702 (3.9) | 17238 (96.1) | 1429 (6.9) | 19214 (93.1) |
| **Total** | **2254 (7.1)** | **29295 (92.9)** |  | **825 (3.9)** | **20067 (96.1)** |  | **1596 (6.9)** | **21492 (93.1)** |  |

**Table 2 Factors associated with the diarrhea status of children using multivariable logistic regression model (MICS 2006, 2012, and 2019)**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Characteristics | 2006 |  | 2012 |  | 2019 |  |
| AOR (95% CI) | P-value | AOR (95% CI) | P-value | AOR (95% CI) | P-value |
| CHILD CHARACTERISTICS | | | | | | |
| Age of child (in months) | |  | |  | |  |
| 0-11 | 1.81 (1.50, 2.18) | **<0.001** | 4.35 (2.10, 9.01) | **<0.001** | 3.32 (2.63, 4.19) | **<0.001** |
| 12-23 | 2.22 (1.86, 2.65) | **<0.001** | 5.24 (2.51, 10.95) | **<0.001** | 3.36 (2.67, 4.22) | **<0.001** |
| 24-35 | 1.45 (1.22, 1.73) | **<0.001** | 1.59 (0.71, 3.59) | 0.261 | 2.26 (1.76, 2.89) | **<0.001** |
| 36-47 | 1.17 (0.97, 1.42) | 0.108 | 2.11 (0.92, 4.82) | 0.077 | 1.52 (1.18, 1.95) | **0.001** |
| 48-59 | Ref. | - | Ref. | - | Ref. | - |
| Child’s sex | |  | |  | |  |
| Male | 1.05 (0.95, 1.16) | 0.351 | - | - | 1.04 (0.92, 1.19) | 0.526 |
| Female | Ref. | - | - | - | Ref. | - |
| Inadequate Supervision | |  | |  | |  |
| Yes | - | - | 1.37 (0.69, 2.73) | 0.368 | 1.18 (0.94, 1.48) | 0.148 |
| No | - | - | Ref. | - | Ref. | - |
| Underweight | |  | |  | |  |
| Yes | - | - | - | - | 1.44 (1.20, 1.73) | **<0.001** |
| No | - | - | - | - | Ref. | - |
| Stunned | |  | |  | |  |
| Yes | - | - | - | - | 0.93 (0.77, 1.10) | 0.385 |
| No | - | - | - | - | Ref. | - |
| Wasted | |  | |  | |  |
| Yes | - | - | 1.61 (0.92, 2.84) | 0.097 | 0.89 (0.72, 1.10) | 0.294 |
| No | - | - | Ref. | - | Ref. | - |
| Overweight | |  | |  | |  |
| No | - | - | 3.46 (0.40, 29.65) | 0.310 | 1.43 (0.86, 2.38) | 0.165 |
| Yes | - | - | Ref. | - | Ref. | - |
| COMMUNITY CHARACTERISTICS | | | | | | |
| Place of residence | |  | |  | |  |
| Rural | 1.16 (0.65, 2.06) | 0.610 | 1.29 (0.75, 2.23) | 0.363 | - | - |
| Urban | 1.46 (0.81, 2.62) | 0.206 | Ref. | - | - | - |
| Tribal | Ref. | - | - | - | - |  |
| Division | |  | |  | |  |
| Barishal | 1.27 (0.99, 1.63) | 0.063 | 0.67 (0.27, 1.63) | 0.375 | 2.51 (1.74, 3.63) | **<0.001** |
| Chattogram | 1.09 (0.87, 1.36) | 0.439 | 1.01 (0.47, 2.20) | 0.973 | 1.33 (0.94, 1.90) | 0.112 |
| Dhaka | 0.96 (0.78, 1.19) | 0.724 | 1.01 (0.46, 2.16) | 0.999 | 0.91 (0.64, 1.30) | 0.597 |
| Khulna | 0.65 (0.50, 0.85) | **0.002** | 0.93 (0.41, 2.13) | 0.862 | 1.05 (0.72, 1.53) | 0.814 |
| Mymensingh | - | - | - | - | 1.22 (0.84, 1.79) | 0.296 |
| Rajshahi | 1.04 (0.83, 1.28) | 0.754 | 0.90 (0.36, 2.22) | 0.811 | 0.93 (0.64, 1.35) | 0.702 |
| Rangpur | - | - | 1.42 (0.63, 3.17) | 0.397 | 0.59 (0.40, 0.88) | **0.010** |
| Sylhet | Ref. | - | Ref. | - | Ref. | - |
| PARENTAL CHARACTERISTICS | | | | | | |
| Mother’s Education | |  | |  | |  |
| Non-standard curriculum | 2.58 (1.21, 5.51) | 0.015 | - | - | - | - |
| Primary incomplete | 1.29 (0.98, 1.69) | 0.064 | - | - | 1.21 (0.91, 1.61) | 0.188 |
| Primary complete | 1.19 (0.87, 1.63) | 0.266 | - | - | 1.08 (0.86, 1.36) | 0.518 |
| Secondary incomplete | 1.11 (0.86, 1.44) | 0.421 | - | - | 1.09 (0.88, 1.34) | 0.426 |
| Secondary complete or higher | Ref. | - | - | - | Ref. | - |
| Mother’s Age at the Survey Time | |  | |  | |  |
| 15-19 | - | - | 1.57 (0.69, 3.57) | 0.280 | - | - |
| 20-34 | - | - | 1.46 (0.77, 2.74) | 0.243 | - | - |
| 35+ | - | - | Ref | - | - | - |
| HOUSEHOLD CHARACTERISTICS | | | | | | |
| Wealth Index | |  | |  | |  |
| Poorest | 1.30 (1.01, 1.65) | **0.038** | - | - | 1.14 (0.90, 1.44) | 0.277 |
| Second | 1.13 (0.89, 1.44) | 0.325 | - | - | 1.32 (1.04, 1.66) | **0.020** |
| Middle | 1.12 (0.89, 1.41) | 0.331 | - | - | 0.95 (0.75, 1.20) | 0.667 |
| Fourth | 0.90 (0.71, 1.14) | 0.373 | - | - | 1.03 (0.81, 1.32) | 0.791 |
| Richest | Ref. | - | - | - | Ref. | - |
| Religion | |  | |  | |  |
| Islam | 1.05 (0.82, 1.35) | 0.684 | - | - | 1.39 (1.02, 1.88) | **0.036** |
| Others | Ref. | - | - | - | Ref. | - |
| Household Head Sex | |  | |  | |  |
| Male | - | - | - | - | 1.20 (0.92, 1.55) | 0.174 |
| Female | - | - | - | - | Ref. | - |
| Ethnicity | |  | |  | |  |
| Bengali | 1.27 (0.76, 2.13) | 0.684 | - | - | 0.59 (0.34, 1.01) | 0.056 |
| Other | Ref. | - | - | - | Ref. | - |
| Toilet facilities shared | |  | |  | |  |
| Yes | 1.07 (0.96, 1.20) | 0.210 | 0.60 (0.36, 0.99) | **0.047** | 1.23 (1.07, 1.42) | **0.004** |
| No | Ref. | - | Ref | - | Ref. | - |
| Toilet facility type | |  | |  | |  |
| Non-improved | 1.23 (1.08, 1.40) | 0.002 | - | - | 1.49 (1.08, 2.05) | **0.015** |
| Improved | Ref. | - | - | - | Ref. | - |
| Salt Iodization | |  | |  | |  |
| No | 1.13 (0.98, 1.30) | 0.103 | - | - | 1.15 (0.99, 1.34) | 0.065 |
| Yes | Ref. | - | - | - | Ref. | - |
| Mass Media | |  | |  | |  |
| No | - | - | - | - | 0.99 (0.87, 1.14) | 0.920 |
| Yes | - | - | - | - | Ref. | - |
| Household size | |  | |  | |  |
| 5/5+ | - | - | 1.13 (0.72, 1.77) | 0.595 | 0.91 (0.79, 1.04) | 0.171 |
| <5 | - | - | Ref. | - | Ref. | - |
| Livestock ownership | |  | |  | |  |
| Yes | - | - | - | - | - | - |
| No | - | - | - | - | - | - |
| Source water type | |  | |  | |  |
| Improved | - | - | - | - | - | - |
| Unimproved | - | - | - | - | - | - |
| Source of water | |  | |  | |  |
| Direct from source | - | - | 1.28 (0.53, 3.08) | 0.580 | - | - |
| Covered container | - | - | 1.37 (0.83, 2.27) | 0.218 | - | - |
| Uncovered container | - | - | Ref. | - | - | - |
| Water treatment | |  | |  | |  |
| Yes | - | - | - | - | - | - |
| No | - | - | - | - | - | - |

AOR: Adjusted odds ratio

**Table 3: Area under ROC Curve, AIC, and BIC for the final logistic regression model.**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Survey Year | The area under the ROC Curve | | AIC | BIC |
| AUC | P-value |
| MICS 2006 | 0.6210 | <0.001 | 14320.83 | 14545.55 |
| MICS 2012 | 0.6826 | <0.001 | 1167.66 | 1295.21 |
| MICS 2019 | 0.6717 | <0.001 | 9610.21 | 9870.85 |

The list of enumeration areas (EAs) for the total population of Bangladesh from Census of 2001 and 2011 and update household list within EAs in 2006, 2012, and 2018.

The main Sampling strata for the two-stage sampling were urban and rural areas within districts.

Within each enumeration area (EA), 20 households were sampled using systematic sampling.

68,247, 55,120, 64,400 households were selected from the EAs in the sample 2006, 2012-13, and 2019 survey years, respectively.

62,463, 51,895, and 61,242 households were completely interviewed with response rate of 92.5%, 98.5%, and 99.4%, respectively.

34,710, 23,402, and 24,686 children under age five were selected in the sample from the interviewed households 2006, 2012-13, and 2019 of survey years, respectively.

Completed data found from 31, 566, 20,903, and 23,099 children given a response rate of 90.9%, 89.3%, and 93.6%, respectively.

**Figure 1: Study population and selection of sample for MICS 2006, 2012-13, and 2019**

|  |
| --- |
|  |

**Figure 2. Forest plot of Adjusted Odds ratios (ORs) and 95% confidence intervals (CIs) for factors associated with the diarrhea status of children (MICS 2006, 2012, and 2019)**

|  |  |  |
| --- | --- | --- |
|  |  |  |
| MICS 2006 | MICS 2012 | MICS 2019 |
| **Figure 3. Sensitivity analysis of fitted final multivariable logistic regression model** | | |