**Evaluation of Contributory Factors of Diarrhea among Under-Five Children in Bangladesh based on Three Waves of Nationally Represent Data**

Mohammad Nayeem Hasan1\*, Mst. Farzana Akter2\*, M. Noor-e-alam Siddiqui1, Sabikunnaher Mitu3, Muhammad Abdul Baker Chowdhury1,4, Md Jamal Uddin1,5\*\*

1Department of Statistics, Shahjalal University of Science & Technology, Sylhet-3114, Bangladesh.

2Department of Community Health Sciences, University of Manitoba, Winnipeg, Manitoba, Canada

3Department of Sociology, Shahjalal University of Science & Technology, Sylhet-3114, Bangladesh.

4Department of Neurosurgery, University of Florida College of Medicine, Gainesville, FL, USA.

5Department of General Educational and Development, Daffodil International University, Dhaka, Bangladesh

\*Equal contributions

**\*\*Corresponding Author: Md Jamal Uddin;** [**jamal-sta@sust.edu**](mailto:jamal-sta@sust.edu)**; Department of Statistics, Shahjalal University of Science and Technology, Sylhet-3114, Bangladesh.**

**Abstract**

One-third of all child deaths in Bangladesh are caused by diarrhea. Little is known about the trends of incidence of diarrheal diseases. We investigated trends and contributory factors of diarrheal diseases among 0-5 years old children in three different years, 2006, 2012, and 2019.In this study, 31,566, 23,402, and 24,686 children under five were included from Multiple Indicator Cluster Survey (MICS) 2006, 2012-13, and 2019 respectively. We used "diarrhea" as the outcome variable, which has two categories: “Yes” for having diarrhea and “No” for not having diarrhea. Univariate and multivariate logistic regressions were applied to analyze the changes of factors influencing childhood diarrhea. The diarrheal status decreased from 2006 (7.1%) to 2012 (3.9%). However, it increased to 6.9% in 2019. We discovered that children aged 12-23 months were 2.22 times (adjusted odds ratio (AOR) = 2.22, 95% confidence interval (CI: 1.86 – 2.65), 5.24 times (AOR = 5.24, CI: 2.51 – 10.95) and 3.36 times (AOR = 3.36, CI: 2.67 – 4.22) more likely to experience diarrhea than a higher age group (48-59 months) in MICS data of 2006, 2012 and 2019, respectively. Moreover, for MICS 2006, 2012, and 2019, children from the mother with no educational background or primary incomplete had 1.48 (CI: 1.18 - 1.86), 1.07 (CI: 0.76 - 1.50), and 1.34 (1.06 – 1.69) times higher chances of having diarrhea than children from secondary complete or higher educational status mothers’ group according to crude odds ratio. Being underweight, division, household wealth status, and toilet facility type and its shared status were contributory factors of diarrhea among 0-5 years old children. To decrease the under-five mortality rate due to diarrhea, child nutrition, basic hygiene practice, and special care for under-five children during rainy season have chances to be fruitful.

**Keywords:** Children, Diarrhea, Trend, Determinant, Bangladesh.

**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 [1]. [2]Each year in developing countries, almost 2 million people die of diarrhea, a significant number of whom are children aged between 0-5 years [3]. The diarrhea-related mortality rate is high in developing countries and deaths from diarrhea is rare in developed countries [3,4]. Due to high mortality rates in the 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 [5]. It was responsible for 9% of 5.8 million child deaths globally and 6% of 0.119 million child deaths in Bangladesh in 2015 [6].

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 [7]. In a developing country like Bangladesh, mostly children suffer from diarrheal diseases which ultimately lead them to death [8]. Each year, in Bangladesh, every child suffers three to five times on an average from diarrheal attacks [9]. Most of the deaths due to diarrhea occur in rural areas [8]. Previous study showed that diarrhea is the reason behind about 33% of total child death in Bangladesh [10]. On average, diarrhea happens more than 4 times per year to a rural child, which results in 2,30,000 child deaths [10]. According to 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 the girls [11].

Being a developing country, Bangladesh has several resource constraints, such as- high density of population (3,277 people per meter squares [12]), poverty, lack of awareness, food deficiency, malnutrition etc. Moreover, in Bangladesh, an approximate of 2.5 million people suffer from basic sanitation issues, and about one million people are unable to have potable water [10]. Previous studies in Bangladesh showed that age, sex, geographic location, drinking from unprotected water supply, sanitation, hygiene, and household economic status can cause diarrhea among children between 0-5 years [10,13].

Young children in Bangladesh generally experience a variety of common illnesses like fever, cough, short/difficult breathing, diarrhea, etc [14,15]. Previous studies on diarrhea found several risk factors which were rainy season [16–18], partial breastfeeding and early weaning [16,17,19,20], lower education level of mother [16,18,21], outdoor drinking water source like river, outdoor faucet [16,18,20,22,23], distance of drinking water source [20], unprotected water storage container [18,20,23,24], not treating drinking water [20,22], larger household size [25], lower household income [25,26], having dirt/wood/bark as floor material [18], not having antenatal care during pregnancy [26], unimproved sanitation system [24,26,27], wastewater to septic tank/street [22], disposal of child faces indiscriminately [23,28], no hand washing facility [20], and unhealthy home environment (garbage and flies near home) [20]. It was identified that boys and younger children had higher risk of having diarrhea [16,29]. To reduce the 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 of factors influencing diarrhea over time. We intended to explore the relationship between diarrhea and some important features e.g., drinking water source, health of children, economic status of household, environment of household etc. we also aimed to examine the change in the status of diarrhea and the contributory factors causing diarrheal disease among the children aged 0-5 years in Bangladesh from 2006 to 2019. Hopefully, this study will help policy makers to focus on interventions that are feasible and can be implemented to reduce the risk.

**Methods**

**Data**

We used secondary data of year 2006, 2012-13 and 2019 of MICS of Bangladesh. Bangladesh Bureau of Statistics (BBS) and Ministry of Planning have been conducting MICS since 1993. As it was a part of global MICS program, BBS worked with 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”* [30].

The sampling procedure was two-stage stratified cluster sampling covering urban and rural areas of Bangladesh where enumeration areas (EAs) were selected at first stage and households with each selected EAs were selected at second stage. In the survey of 2006, the sample included 68,247 households, among which 67,540 had people to be interviewed. Among them, 62, 463 households were successfully completed the survey with response rate of 92.5 percent. In total, 31,566 children under age 5 were completed the questionnaire among 34,710 children identified from interviewed households with response rate of 90.9 percent. In the survey of 2012-2013, the sample covered 55,120 households from which 52,711 households had people to attend the interview and out of these, 51,895 were completely interviewed with response rate of 98.5 percent. In total 23,402 children under age five were selected in the sample but completed data found from 20,903 children given a response rate of 89.3 percent among visited households. The sample of 2019 survey selected 64,400 households and people were inhabited in 61,602 households of them. Among those, 61,242 household completed the survey with response rate of 99.4 percent. 24,686 children under age five were included in household survey and among them completed information of 23,099 children were found with response rate of 93.6 percent [**Figure 1**].

**Questionnaires**

The MICS tools [31] of round MICS3 were used in the survey of 2006, MICS5 in 2012-2013 and MICS6 in 2019 for Bangladesh. The round MICS3 had three questionnaires: i) household questionnaire which included information of the characteristics of household, ii) questionnaire for individual women which covered information of every woman aged 15-49 years in each household, and iii) questionnaire for children under five which covered each children’s overall information. The round MICS5 used four sets of questionnaire and along with the three questionnaires of MICS3 round, another questionnaire was for testing water quality which used to find out the arsenic and E. coli content in potable water of household. The round MICS6 used five questionnaires and the addition in this round was collecting information of one randomly selected child from 5-17 years age group from each household. All questionnaires were interpreted into Bangla.

**Outcome and possible covariates**

**Outcome variable**

Diarrhea is determined as whether 0-5 years old children had diarrhea in past two weeks or not and the answer is given by mothers or caretakers of children. We considered binary variable “Diarrhea” as the outcome variable. Here, the Diarrhea variable has two categories: “Yes” for having diarrhea and “No” for not having diarrhea in past two weeks for the children under age five.

**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 [10,13,16–29].

A child had inadequate supervision if the child was not with any adult for more than one hour at least once during 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 [32]. The z-scores measures 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 [33].

Flushed to 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 [30]. 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 for 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 improved water source and dug well (unprotected), unprotected spring, tanker truck, cart with small tank, water selling plant, surface water (river, dam, lake, pond, canal) and other were considered as unimproved water source. Drinking water was considered treated if any process among boiling, adding bleach/chlorine, straining through cloth, using any kind of water filter was done [30].

**Data analysis**

Stata Statistical software for data science version 17.0 had been used for data analysis.. We applied univariate and multivariate logistic regressions to analyze the association between diarrhea and the selected covariates at 5% significance level for each dataset. Covariates statistically significant at univariate logistic regression were considered as potential covariates in a multivariate logistic regression analysis. The final model output was represented in a forest-plot.

The procedure of choosing best model was step-wise logistic regression, and it included the factors found relevant and important to explain the behavior of the outcome variable from literature review. The measures of sensitivity and specificity from the Receiver Operating Characteristic (AUROC) curve, are used to assess the optimal model. The models performed better, according to the higher ROC regions. A bigger area under the curve than the 0.50 on the ROC curve indicates that the model discriminates between the two groups [34]. We also employ information criteria, e.g., the Akaike information criterion (AIC [35]) and Bayesian information criterion (BIC [36]) as a goodness-of-fit measure for the final multivariate logistic model.

We used Stata command (Svyset) of the survey data reference manual to accounting for the complex survey settings of the datasets [37]. Svyset commands were developed for STATA to consider the survey design elements such as sample weights, PSU, clusters and strata [38].

**Results**

The occurrence of diarrhea among 0-5 years 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. Among underweight children, 8.5% of them had diarrhea in the MICS data of 2019, which was 4.0% in the MICS data of 2012. Based on the division in Barisal 8.9%, 6.3%, 14.1% children had diarrhea respectively as reported highest in 2006, 2012 and 2019 MICS data. Likewise, the MICS data from 2006, 2012, 2019 reported that in the Khulna division 4.4%, 3.3%, and 6.5% of under-five children had lowest diarrhea respectively. Among the under-five children whose mother's educational level was secondary completed or higher 5.5%, 3.9%, and 5.9% of them had lowest diarrhea in 2006, 2012, and 2019. 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 lowest diarrhea in the survey time of 2006, in contrast, it was lowest 3.4% in middle and 5.5% in richest families in 2012 and 2019, respectively. Among the children under 5 years whose family didn’t consume adequately iodized salt 8.6% of them had highest prevalence of diarrhea in 2006 which was decreased to 8.0% in 2019, but lowest in 2012, 3.8%.

From the univariate model, we have found that the age of the child, underweight, area of 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.



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. The odds of having diarrhea for the children of all age group was higher than the children of 48-59 months respectively in all survey years. Compared with the children under age 5 from the Sylhet division in 2006, 2012, and 2019 survey, children of 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 2012 survey, children of Barisal division had 33% (AOR: 0.67, 95% CI: 0.27-1.63) times lower chance of having diarrhea. Children from 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 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 3 and Figure 3).



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 2). 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 good fit, and a normal binary logistic model with variables included in this survey model suggested to use to describe this type of analysis (Table 4).

**Discussion:**

There was a decrease in the occurrence of diarrhea from 2006 to 2012 and an increase in 2019 among 0-5 years old children in Bangladesh. The occurrence of diarrhea was higher for 12-23 months’ children, followed by 0-11 month’s children, and the difference is significant compared with children of 48-59 months age group in 2006, 2012 and 2019. Children of 0-24 months age group are in the process of developing immune systems and depend on their mothers to be protected [39]. 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 [40]. The findings from previous studies in Bangladesh, Ethiopia, Niger, Nigeria, Cameroon, and Ghana were similar to this [13,40–44].

In 2006, the chance of having diarrhea was significantly higher for children from the poorest families and children from households without improved toilet facilities. Children from poor families have more probability to be 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 [13,40,45,46]. Previous studies on Ethiopia and several developing countries reported similar scenario [5,40,47]. 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 with the chance of having diarrhea among children [47]. 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 [48–52]. 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. This finding contradicts the idea that sharing one facility with multiple families increases the chance of affecting each other by the viruses causing diarrhea [53]. However, it is not sure that the shared toilet facility caused diarrhea, but the unhygienic toilet facility contains the pathogens like norovirus, which caused diarrhea [53]. The toilet facility, whether shared or private, must be hygienic, and the people using the toilet must practice hand washing after using the toilet [54]. Households using shared toilet facilities might prioritize hand washing practices over other households, which could cause the findings. In 2019, children from the second wealth index and those from households that used unimproved and/or shared toilet facilities were more at risk of experiencing diarrhea.

In 2019, the chance of having diarrhea was significantly higher for underweight children. Being underweight depicts the malnourished status of a child, and malnourished children are prone to infectious diseases due to the lack of proper nutrition and weak immune system. Underweight children were more likely to have diarrhea due to the malnourished condition, and previous studies conducted in Bangladesh supported these findings [55–57]. 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. The water-borne diseases like diarrhea are more observed in water-prone areas like the northeastern and southern parts of Bangladesh [58]. 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 [59]. The chance of having diarrhea was higher for children from these places than in other parts of Bangladesh. We found that Muslim children were more at risk of having diarrhea in 2019. More than 90 percent of children were from Muslim families, and due to the unbalanced status of this factor, the finding related to this lacks accuracy [60]. To accurately assess the effect of religion on the prevalence of diarrhea through logistic regression require balanced data in terms of this factor or application of modified machine learning methods.

**Strengths and limitations:**

According to our knowledge, MICS data, known to be perfectly comparable with Demographic Health Survey data and used for global statistics, were analyzed to fulfill the research purpose. 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. More information was needed about mothers' health to depict the actual picture.

**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. 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. Implementing these measures can also reduce hospital burden. Additionally, efforts should be reassessed and stepped up to improve sanitary infrastructure, personal and food hygiene, and home waste management. Another choice, though pricy, is the creation and widespread distribution of vaccinations against Bangladesh's most prevalent diarrheagenic pathogens. Clinicians and caregivers may be better equipped to intervene when an illness is still in its early stages if they are able to identify children becoming extremely dehydrated.

**Conclusion:**

Our study demonstrated that factors such as 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 years 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 higher chance of having diarrhea. Private and improved toilet facilities, hygiene practices, and proper nutrition for children can reduce childhood diarrhea. The findings of our study have some potential implications for our policymakers. Different government and non-government organizations, international agencies, and public health professionals work to improve children's health. Implementation of program regarding basic hygiene practice and child nutrition along with existing program can make substantial changes in childhood diarrhea.

**Acknowledgments**

We acknowledge UNICEF and the Bangladesh Bureau of Statistics for allowing us to use the data.

**Ethical consent**

Our study was wholly based on an analysis of existing public domain health survey datasets obtained from the MICS 2006, 2012 and 2019 which is freely available online with all personal identifying information removed. The MICS procedures were reviewed and approved by the Bangladesh Bureau of Statistics (BBS) and UNICEF. Informed consent was obtained from participants while interviewing them. Because this study involved the analysis with secondary data thus, it did not require the ethical approval of the respective institution.

**Disclosure statement**

No potential conflict of interest was reported by the authors.

**Author Contributions**

Mst. Farzana Akter, Mohammad Nayeem Hasan, M. Noor-e-alam Siddiqui, Sabikunnaher Mitu, Muhammad Abdul Baker Chowdhury, and Md Jamal Uddin: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Software, Supervision, Validation, Visualization, Roles/Writing - original draft, Writing - review and editing.

**Funding**

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

**Reference:**

[1] Woldu W, Bitew BD, Gizaw Z. Socioeconomic factors associated with diarrheal diseases among under-five children of the nomadic population in northeast Ethiopia. Tropical Medicine and Health 2016;44:40. https://doi.org/10.1186/s41182-016-0040-7.

[2] Farthing M, Salam MA, Lindberg G, Dite P, Khalif I, Salazar-Lindo E, et al. Acute diarrhea in adults and children: a global perspective. J Clin Gastroenterol 2013;47:12–20. https://doi.org/10.1097/MCG.0b013e31826df662.

[3] Zeleke AT, Alemu ZA. Determinants of Under-Five Childhood Diarrhea in Kotebe Health Center, Yeka Sub City, Addis Ababa, Ethiopia: A Case Control Study. Global Journal of Medical Research 2014;14.

[4] Podewils LJ, Mintz ED, Nataro JP, Parashar UD. Acute, infectious diarrhea among children in developing countries. Semin Pediatr Infect Dis 2004;15:155–68. https://doi.org/10.1053/j.spid.2004.05.008.

[5] Pinzón-Rondón ÁM, Zárate-Ardila C, Hoyos-Martínez A, Ruiz-Sternberg ÁM, Vélez-van-Meerbeke A. Country characteristics and acute diarrhea in children from developing nations: a multilevel study. BMC Public Health 2015;15:811. https://doi.org/10.1186/s12889-015-2120-8.

[6] Alam T, Ahmed T, Sarmin M, Shahrin L, Afroze F, Sharifuzzaman, et al. Risk Factors for Death in Bangladeshi Children Under 5 Years of Age Hospitalized for Diarrhea and Severe Respiratory Distress in an Urban Critical Care Ward. Glob Pediatr Health 2017;4:2333794X17696685. https://doi.org/10.1177/2333794X17696685.

[7] Diarrhoea. UNICEF DATA n.d. https://data.unicef.org/topic/child-health/diarrhoeal-disease/ (accessed August 6, 2022).

[8] Shah SM, Yousafzai M, Lakhani NB, Chotani RA, Nowshad G. Prevalence and correlates of diarrhea. Indian J Pediatr 2003;70:207–11. https://doi.org/10.1007/BF02725583.

[9] Alam MJ. Water quality tests and behavioral factors of child diarrhoea in Dhaka slums 2007.

[10] Islam MR, Hossain MK, Khan MN, Ali MR. An Evidence of Socio-Demographic Effects on Child’s Diarrhoea in Bangladesh. Journal of Health Science 2015;5:1–5.

[11] Begum S, Ahmed M, Sen B. Do Water and Sanitation Interventions Reduce Childhood Diarrhoea? New Evidence from Bangladesh. The Bangladesh Development Studies 2011;34:1–30.

[12] Bangladesh Population (2022) - Worldometer n.d. https://www.worldometers.info/world-population/bangladesh-population/ (accessed August 6, 2022).

[13] Rahman A, Hossain MM. Prevalence and determinants of fever, ARI and diarrhea among children aged 6–59 months in Bangladesh. BMC Pediatr 2022;22:1–12. https://doi.org/10.1186/s12887-022-03166-9.

[14] Hasan MN, Chowdhury MAB, Jahan J, Jahan S, Ahmed NU, Uddin MJ. Cesarean delivery and early childhood diseases in Bangladesh: An analysis of Demographic and Health Survey (BDHS) and Multiple Indicator Cluster Survey (MICS). PLOS ONE 2020;15:e0242864. https://doi.org/10.1371/journal.pone.0242864.

[15] Islam MdA, Hasan MN, Ahammed T, Anjum A, Majumder A, Siddiqui MN-E-A, et al. Association of household fuel with acute respiratory infection (ARI) under-five years children in Bangladesh. Frontiers in Public Health 2022;10.

[16] Mølbak K, Jensen H, lngholt L, Aaby P. Risk Factors for Diarrheal Disease Incidence in Early Childhood: A Community Cohort Study from Guinea-Bissau. American Journal of Epidemiology 1997;146:273–82. https://doi.org/10.1093/oxfordjournals.aje.a009263.

[17] Guerrant RL, Kirchhoff LV, Shields DS, Nations MK, Leslie J, de Sousa MA, et al. Prospective study of diarrheal illnesses in northeastern Brazil: patterns of disease, nutritional impact, etiologies, and risk factors. J Infect Dis 1983;148:986–97. https://doi.org/10.1093/infdis/148.6.986.

[18] Kosek M, Yori PP, Pan WK, Olortegui MP, Gilman RH, Perez J, et al. Epidemiology of Highly Endemic Multiply Antibiotic-Resistant Shigellosis in Children in the Peruvian Amazon. Pediatrics 2008;122:e541–9. https://doi.org/10.1542/peds.2008-0458.

[19] VanDerslice J, Popkin B, Briscoe J. Drinking-water quality, sanitation, and breast-feeding: their interactive effects on infant health. Bull World Health Organ 1994;72:589–601.

[20] Maponga BA, Chirundu D, Gombe NT, Tshimanga M, Shambira G, Takundwa L. Risk factors for contracting watery diarrhoea in Kadoma City, Zimbabwe, 2011: a case control study. BMC Infect Dis 2013;13:1–8. https://doi.org/10.1186/1471-2334-13-567.

[21] Dargent-Molina P, James SA, Strogatz DS, Savitz DA. Association between maternal education and infant diarrhea in different household and community environments of Cebu, Philippines. Soc Sci Med 1994;38:343–50. https://doi.org/10.1016/0277-9536(94)90404-9.

[22] Tornheim JA, Morland KB, Landrigan PJ, Cifuentes E. Water Privatization, Water Source, and Pediatric Diarrhea in Bolivia: Epidemiologic Analysis of a Social Experiment. International Journal of Occupational and Environmental Health 2009;15:241–8. https://doi.org/10.1179/oeh.2009.15.3.241.

[23] Ghosh S, Sengupta PG, Mondal SK, Banu MK, Gupta DN, Sircar BK. Risk behavioural practices of rural mothers as determinants of childhood diarrhoea. J Commun Dis 1997;29:7–14.

[24] D’Souza RM. Housing and environmental factors and their effects on the health of children in the slums of Karachi, Pakistan. J Biosoc Sci 1997;29:271–81. https://doi.org/10.1017/s002193209700271x.

[25] Blake PA, Ramos S, MacDonald KL, Rassi V, Gomes TA, Ivey C, et al. Pathogen-specific risk factors and protective factors for acute diarrheal disease in urban Brazilian infants. J Infect Dis 1993;167:627–32. https://doi.org/10.1093/infdis/167.3.627.

[26] Genser B, Strina A, Teles CA, Prado MS, Barreto ML. Risk factors for childhood diarrhea incidence: dynamic analysis of a longitudinal study. Epidemiology 2006;17:658–67. https://doi.org/10.1097/01.ede.0000239728.75215.86.

[27] Sobel J, Gomes T a. T, Ramos RTS, Hoekstra M, Rodrigue D, Rassi V, et al. Pathogen-specific risk factors and protective factors for acute diarrheal illness in children aged 12-59 months in São Paulo, Brazil. Clin Infect Dis 2004;38:1545–51. https://doi.org/10.1086/420822.

[28] Majorin F, Torondel B, Ka Seen Chan G, Clasen T. Interventions to improve disposal of child faeces for preventing diarrhoea and soil‐transmitted helminth infection. Cochrane Database Syst Rev 2019;2019:CD011055. https://doi.org/10.1002/14651858.CD011055.pub2.

[29] Quick RE, Venczel LV, Mintz ED, Soleto L, Aparicio J, Gironaz M, et al. Diarrhoea prevention in Bolivia through point-of-use water treatment and safe storage: a promising new strategy. Epidemiol Infect 1999;122:83–90.

[30] Surveys - UNICEF MICS n.d. https://mics.unicef.org/surveys (accessed June 23, 2022).

[31] Tools - UNICEF MICS n.d. http://mics.unicef.org/tools (accessed August 27, 2017).

[32] The WHO Child Growth Standards n.d. https://www.who.int/tools/child-growth-standards/standards (accessed August 10, 2022).

[33] WHO child growth standards: training course on child growth assessment n.d. https://www.who.int/publications-detail-redirect/9789241595070 (accessed January 21, 2023).

[34] Cook JA, Rajbhandari A. Heckroccurve: ROC Curves for Selected Samples. The Stata Journal 2018;18:174–83. https://doi.org/10.1177/1536867X1801800110.

[35] Akaike H. A new look at the statistical model identification. IEEE Transactions on Automatic Control 1974;19:716–23. https://doi.org/10.1109/TAC.1974.1100705.

[36] Schwarz G. Estimating the Dimension of a Model. The Annals of Statistics 1978;6:461–4.

[37] Stata Bookstore | Survey Data Reference Manual, Release 17 n.d. https://www.stata.com/bookstore/survey-data-reference-manual/ (accessed August 13, 2022).

[38] Survey Data Analysis in Stata n.d. https://stats.oarc.ucla.edu/stata/seminars/svy-stata-8/ (accessed January 21, 2023).

[39] Siziya S, Muula AS, Rudatsikira E. Diarrhoea and acute respiratory infections prevalence and risk factors among under-five children in Iraq in 2000. Ital J Pediatr 2009;35:8. https://doi.org/10.1186/1824-7288-35-8.

[40] Negesse Y, Taddese AA, Negesse A, Ayele TA. Trends and determinants of diarrhea among under-five children in Ethiopia: cross-sectional study: multivariate decomposition and multilevel analysis based on Bayesian approach evidenced by EDHS 2000–2016 data. BMC Public Health 2021;21:193. https://doi.org/10.1186/s12889-021-10191-3.

[41] Tambe AB, Nzefa LD, Nicoline NA. Childhood Diarrhea Determinants in Sub-Saharan Africa: A Cross Sectional Study of Tiko-Cameroon. Challenges 2015;6:229–43. https://doi.org/10.3390/challe6020229.

[42] Caruso B, Stephenson R, Leon JS. Maternal behavior and experience, care access, and agency as determinants of child diarrhea in Bolivia. Rev Panam Salud Publica 2010;28:429–39. https://doi.org/10.1590/S1020-49892010001200004.

[43] Bado AR, Susuman AS, Nebie EI. Trends and risk factors for childhood diarrhea in sub-Saharan countries (1990–2013): assessing the neighborhood inequalities. Global Health Action 2016;9:30166. https://doi.org/10.3402/gha.v9.30166.

[44] Melese B, Paulos W, Astawesegn FH, Gelgelu TB. Prevalence of diarrheal diseases and associated factors among under-five children in Dale District, Sidama zone, Southern Ethiopia: a cross-sectional study. BMC Public Health 2019;19:1235. https://doi.org/10.1186/s12889-019-7579-2.

[45] Guerrant RL, DeBoer MD, Moore SR, Scharf RJ, Lima AAM. The impoverished gut--a triple burden of diarrhoea, stunting and chronic disease. Nat Rev Gastroenterol Hepatol 2013;10:220–9. https://doi.org/10.1038/nrgastro.2012.239.

[46] Iannotti LL, Trehan I, Clitheroe KL, Manary MJ. Diagnosis and treatment of severely malnourished children with diarrhoea. J Paediatr Child Health 2015;51:387–95. https://doi.org/10.1111/jpc.12711.

[47] Bawankule R, Singh A, Kumar K, Pedgaonkar S. Disposal of children’s stools and its association with childhood diarrhea in India. BMC Public Health 2017;17:12. https://doi.org/10.1186/s12889-016-3948-2.

[48] Sinmegn Mihrete T, Asres Alemie G, Shimeka Teferra A. Determinants of childhood diarrhea among underfive children in Benishangul Gumuz Regional State, North West Ethiopia. BMC Pediatrics 2014;14:102. https://doi.org/10.1186/1471-2431-14-102.

[49] Mengistie B, Berhane Y, Worku A. Prevalence of diarrhea and associated risk factors among children under-five years of age in Eastern Ethiopia: A cross-sectional study. Open Journal of Preventive Medicine 2013;3:446–53. https://doi.org/10.4236/ojpm.2013.37060.

[50] Traoré E, Cousens S, Curtis V, Mertens T, Tall F, Traoré A, et al. Child defecation behaviour, stool disposal practices, and childhood diarrhoea in Burkina Faso: results from a case-control study. Journal of Epidemiology & Community Health 1994;48:270–5. https://doi.org/10.1136/jech.48.3.270.

[51] Fobil JN, Kraemer A, Meyer CG, May J. Neighborhood Urban Environmental Quality Conditions Are Likely to Drive Malaria and Diarrhea Mortality in Accra, Ghana. Journal of Environmental and Public Health 2011;2011:484010. https://doi.org/10.1155/2011/484010.

[52] Geruso M, Spears D. Neighborhood sanitation and infant mortality. American Economic Journal: Applied Economics 2018;10:125–62.

[53] Just MR, Carden SW, Li S, Baker KK, Gambhir M, Fung IC-H. The impact of shared sanitation facilities on diarrheal diseases with and without an environmental reservoir: a modeling study. Pathog Glob Health 2018;112:195–202. https://doi.org/10.1080/20477724.2018.1478927.

[54] Baker KK, O’Reilly CE, Levine MM, Kotloff KL, Nataro JP, Ayers TL, et al. Sanitation and Hygiene-Specific Risk Factors for Moderate-to-Severe Diarrhea in Young Children in the Global Enteric Multicenter Study, 2007–2011: Case-Control Study. PLOS Medicine 2016;13:e1002010. https://doi.org/10.1371/journal.pmed.1002010.

[55] Ferdous F, Das SK, Ahmed S, Farzana FD, Latham JR, Chisti MJ, et al. Severity of Diarrhea and Malnutrition among Under Five-Year-Old Children in Rural Bangladesh. Am J Trop Med Hyg 2013;89:223–8. https://doi.org/10.4269/ajtmh.12-0743.

[56] Ahmed T, Mahfuz M, Ireen S, Ahmed AMS, Rahman S, Islam MM, et al. Nutrition of children and women in Bangladesh: trends and directions for the future. J Health Popul Nutr 2012;30:1–11. https://doi.org/10.3329/jhpn.v30i1.11268.

[57] Mata L. Diarrheal disease as a cause of malnutrition. Am J Trop Med Hyg 1992;47:16–27. https://doi.org/10.4269/ajtmh.1992.47.16.

[58] Das S, Chandra H, Saha UR. District level estimates and mapping of prevalence of diarrhoea among under-five children in Bangladesh by combining survey and census data. PLOS ONE 2019;14:e0211062. https://doi.org/10.1371/journal.pone.0211062.

[59] Islam MA, Hoque MA, Ahmed KM, Butler AP. Impact of Climate Change and Land Use on Groundwater Salinization in Southern Bangladesh—Implications for Other Asian Deltas. Environmental Management 2019;64:640–9. https://doi.org/10.1007/s00267-019-01220-4.

[60] Salas-Eljatib C, Fuentes-Ramirez A, Gregoire TG, Altamirano A, Yaitul V. A study on the effects of unbalanced data when fitting logistic regression models in ecology. Ecological Indicators 2018;85:502–8. https://doi.org/10.1016/j.ecolind.2017.10.030.

**Tables and figures**

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  | | |  | | |  | | |
|  | |  |  | |  |  | |  |
|  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |
|  | | | | | | | | | |
|  | | | | | | | | | |
|  |  |  |  |  |  |  |  |  |  |
|  | 0 | 90.0 |  |  |  |  |
|  | 4 |  |  |  |  |  |
|  |  |  | 7 |  |  |  |
|  |  |  | 1 |  |  |  |
|  | | | | | | | | | |
|  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |
|  | | | | | | | | | |
|  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |
|  | | | | | | | | | |
|  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |
|  | | | | | | | | | |
|  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |
|  | | | | | | | | | |
|  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |
|  | | | | | | | | | |
|  |  |  |  | 4 |  |  |  |  |  |
|  |  |  |  |  |  |  |
|  | | | | | | | | | |
|  | | | | | | | | | |
|  |  |  |  |  |  |  |  |  |  |
|  |  |  | 16 | 4 |  |  |
|  |  | 40 |  |  |  |  |
|  | | | | | | | | | |
|  |  |  |  |  |  | **2** |  |  |  |
|  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |
|  | | | | | | | | | |
|  | | | | | | | | | |
|  |  |  |  |  |  | 86 |  |  |  |
|  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |
|  |  | 2 |  |  |  |  |  |
|  | | | | | | | | | |
| – | 1 |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |
|  | | | | | | | | | |
|  | | | | | | | | | |
|  | 5 |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |
|  | 6 |  |  |  |  |  |
|  |  |  |  |  |  |  |
|  | | | | | | | | | |
|  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |
|  | | | | | | | | | |
|  |  |  | 0.285 |  |  |  |  |  |  |
|  |  |  |  |  |  |  |
|  | | | | | | | | | |
|  |  |  | 4 |  |  |  |  |  |  |
|  |  |  |  |  |  |  |
|  | | | | | | | | | |
|  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |
|  | | | | | | | | | |
|  |  |  |  |  |  | 868 |  |  |  |
|  | 4 | 97 | 1 1 | 95.9 |  |  |
|  | | | | | | | | | |
|  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |
|  | | | | | | | | | |
|  |  |  |  |  | 7 |  |  |  |  |
|  |  |  |  |  |  |  |
|  | | | | | | | | | |
|  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |
|  | | | | | | | | | |
|  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |
|  | | | | | | | | | |
|  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |
|  | | | | | | | | | |
|  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |
|  | | | | | | | | | |
|  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  | **1** |  |

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

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Characteristics | 2006 |  | 2012 |  | 2019 |  |
| COR (95% CI) | P-value | COR (95% CI) | P-value | COR | P-value |
| CHILD CHARACTERISTICS | |  | |  | |  |
| Age of child (in months) | |  | |  | |  |
| 0-11 | 1.80 (1.51, 2.15) | **<0.001** | 3.96 (2.71, 5.77) | **<0.001** | 2.92 (2.36, 3.60) | **<0.001** |
| 12-23 | 2.16 (1.82, 2.56) | **<0.001** | 5.84 (4.14, 8.25) | **<0.001** | 3.27 (2.64, 4.03) | **<0.001** |
| 24-35 | 1.46 (1.23, 1.72) | **<0.001** | 2.42 (1.68, 3.48) | **<0.001** | 2.21 (1.76, 2.77) | **<0.001** |
| 36-47 | 1.17 (0.97, 1.42) | 0.097 | 1.60 (1.05, 2.42) | **0.027** | 1.57 (1.25, 1.97) | **<0.001** |
| 48-59 | Ref. | - | Ref. | - | Ref. | - |
| Child’s sex | |  | |  | |  |
| Male | 1.08 (0.98, 1.19) | 0.107 | 0.99 (0.84, 1.18) | 0.931 | 1.08 (0.96, 1.22) | 0.178 |
| Female | Ref. | - | Ref. | - | Ref. | - |
| Inadequate Supervision | |  | |  | |  |
| Yes | - |  | 1.36 (0.99, 1.86) | 0.058 | 1.20 (0.98, 1.46) | 0.079 |
| No | - |  | Ref | - | Ref | - |
| Underweight | |  | |  | |  |
| Yes | - |  | 1.02 (0.84, 1.23) | 0.879 | 1.35 (1.19, 1.54) | **<0.001** |
| No | - |  | Ref | - | Ref | - |
| Stunned | |  | |  | |  |
| Yes | - |  | 0.98 (0.81, 1.19) | 0.867 | 1.10 (0.98, 1.25) | 0.132 |
| No | - |  | Ref | - | Ref | - |
| Wasted | |  | |  | |  |
| Yes | - |  | 1.20 (0.94, 1.55) | 0.148 | 1.20 (1.00, 1.43) | 0.053 |
| No | - |  | Ref | - | Ref | - |
| Overweight | |  | |  | |  |
| No | - |  | 1.47 (1.00, 2.18) | 0.051 | 1.30 (1.00, 1.70) | 0.057 |
| Yes | - |  | Ref | - | Ref | - |
| COMMUNITY CHARACTERISTICS | |  | |  | |  |
| Place of residence | |  | |  | |  |
| Rural | 1.43 (1.06, 1.92) | **0.018** | 1.24 (0.96, 1.61) | 0.099 | 1.01 (0.85, 1.19) | 0.896 |
| Urban | 1.50 (1.10, 2.04) | **0.011** | Ref | - | Ref. | - |
| Tribal | Ref. | - | - |  | - | - |
| Division | |  | |  | |  |
| Barishal | 1.21 (0.95, 1.55) | 0.114 | 1.70 (1.22, 2.37) | **0.002** | 2.43 (1.79, 3.30) | **<0.001** |
| Chattogram | 1.01 (0.82, 1.26) | 0.893 | 1.20 (0.87, 1.66) | 0.265 | 1.21 (0.90, 1.62) | 0.213 |
| Dhaka | 0.94 (0.77, 1.16) | 0.579 | 0.91 (0.65, 1.26) | 0.559 | 0.99 (0.65, 1.21) | 0.455 |
| Khulna | 0.57 (0.45, 0.74) | **<0.001** | 0.87 (0.62, 1.23) | 0.429 | 1.02 (0.74, 1.42) | 0.884 |
| Mymensingh | - | - | - | - | 1.41 (1.01, 1.97) | 0.043 |
| Rajshahi | 0.99 (0.81, 1.21) | 0.933 | 0.93 (0.65, 1.31) | 0.666 | 1.04 (0.75, 1.45) | 0.788 |
| Rangpur | - | - | 0.99 (0.71, 1.39) | 0.955 | 0.70 (0.49, 0.98) | **0.037** |
| Sylhet | Ref. | - | Ref | - | Ref | - |
| PARENTAL CHARACTERISTICS | |  | |  | |  |
| Mother’s Education | |  | |  | |  |
| Non-standard curriculum | 2.69 (1.36, 5.31) | **0.004** | - | - | - | - |
| Primary incomplete | 1.48 (1.18, 1.86) | **0.001** | 1.07 (0.76, 1.50) | 0.706 | 1.34 (1.06, 1.69) | **0.013** |
| Primary complete | 1.23 (0.94, 1.60) | 0.133 | 0.93 (0.62, 1.37) | 0.701 | 1.27 (1.04, 1.55) | **0.019** |
| Secondary incomplete | 1.12 (0.88, 1.41) | 0.353 | 0.99 (0.69, 1.41) | 0.937 | 1.18 (0.99, 1.42) | 0.067 |
| Secondary complete or higher | Ref. | - | Ref | - | Ref. | - |
| Mother’s Age at the Survey Time | |  | |  | |  |
| 15 – 19 | 1.08 (0.92, 1.25) | 0.355 | 1.75 (1.22, 2.50) | **0.002** | 1.00 (0.85, 1.18) | 0.952 |
| 20-34 | 0.98 (0.86, 1.10) | 0.694 | 1.43 (1.10, 1.86) | **0.007** | 1.00 (0.87, 1.13) | 0.895 |
| 35+ | Ref. | - | Ref | - | Ref | - |
| HOUSEHOLD CHARACTERISTICS | |  | |  | |  |
| Wealth Index | |  | |  | |  |
| Poorest | 1.42 (1.17, 1.74) | **0.001** | 1.22 (0.89, 1.67) | 0.224 | 1.55 (1.28, 1.89) | **<0.001** |
| Poor | 1.25 (1.01, 1.53) | **0.037** | 0.90 (0.65, 1.25) | 0.539 | 1.52 (1.24, 1.86) | **<0.001** |
| Middle | 1.16 (0.94, 1.43) | 0.164 | 0.83 (0.59, 1.17) | 0.303 | 1.11 (0.90, 1.37) | 0.347 |
| Rich | 0.89 (0.71, 1.12) | 0.322 | 0.92 (0.65, 1.32) | 0.666 | 1.13 (0.91, 1.41) | 0.271 |
| Richest | Ref. | - | Ref | - | Ref | - |
| Religion | |  | |  | |  |
| Islam | 1.22 (0.99, 1.51) | 0.061 | 1.02 (0.76, 1.37) | 0.904 | 1.29 (1.03, 1.62) | **0.026** |
| Others | Ref. | - | Ref | - | Ref | - |
| Household Head Sex | |  | | | |  |
| Male | 1.14 (0.89, 1.47) | 0.285 | 1.06 (0.79, 0.03) | 0.704 | 1.24 (0.98, 1.56) | 0.068 |
| Female | Ref. | - | Ref | - | Ref | - |
| Ethnicity | |  | |  | |  |
| Bengali | 1.28 (0.92, 1.77) | 0.145 | 1.07 (0.59, 1.95) | 0.814 | 0.66 (0.47, 0.94) | **0.020** |
| Other | Ref. | - | Ref | - | Ref | - |
| Toilet facilities shared | |  | |  | |  |
| Yes | 1.14 (1.02, 1.27) | **0.016** | 0.81 (0.66, 0.99) | **0.038** | 1.22 (1.08, 1.38) | **0.001** |
| No | Ref. | - | Ref | - | Ref | - |
| Toilet facility type | |  | |  | |  |
| Non-improved | 1.36 (1.22, 1.52) | **<0.001** | 1.04 (0.63, 1.73) | 0.868 | 1.49 (1.17, 1.91) | **0.002** |
| Improved | Ref. | - | Ref | - | Ref | - |
| Salt Iodization | |  | |  | |  |
| No | 1.27 (1.12, 1.45) | **<0.001** | 0.95 (0.77, 1.16) | 0.601 | 1.24 (1.08, 1.41) | **0.002** |
| Yes | Ref. | - | Ref | - | Ref | - |
| Mass Media | |  | |  | |  |
| No | - |  | 0.98 (0.81, 1.19) | 0.817 | 1.12 (1.00, 1.27) | 0.059 |
| Yes | - | - | Ref | - | Ref | - |
| Household size | |  | |  | |  |
| 5/5+ | 1.06 (0.94, 1.19) | 0.322 | 1.15 (0.95, 1.40) | 0.154 | 0.92 (0.82, 1.04) | 0.191 |
| <5 | Ref. | - | Ref | - | Ref | - |
| Livestock ownership | |  | |  | |  |
| Yes | - | - | 1.03 (0.85, 1.25) | 0.786 | 0.99 (0.88, 1.11) | 0.858 |
| No | - | - | Ref | - | Ref | - |
| Source water type | |  | | | |  |
| Improved | 1.04 (0.69, 1.57) | 0.854 | 1.15 (0.58, 2.31) | 0.688 | 0.91 (0.67, 1.23) | 0.537 |
| Unimproved | Ref. | - | Ref | - | Ref | - |
| Source of water | |  | |  | |  |
| Direct from source | - | - | 1.39 (0.61, 3.15) | 0.431 | 1.40 (0.83, 2.35) | 0.205 |
| Covered container | - | - | 1.60 (1.04, 2.48) | **0.033** | 1.18 (0.87, 1.60) | 0.281 |
| Uncovered container | - | - | Ref | - | Ref | - |
| Water treatment | |  | |  | |  |
| Yes | 1.17 (0.91, 1.49) | 0.214 | 1.18 (0.89, 1.58) | 0.257 | 0.99 (0.81, 1.22) | 0.945 |
| No | Ref. | - | Ref | - | Ref | - |

**Table.3 Factors associated with the diarrhea status of children using multivariate 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 | - | - | - | - | - | - |

**Table 4: Area under ROC Curve, AIC, and BIC for final logistic regression model.**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Survey Year | Area under 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 |

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

|  |  |  |
| --- | --- | --- |
|  |  |  |
| **Figure 2. Sensitivity analysis of fitted final multivariable logistic regression model** | | |

|  |
| --- |
|  |
| **Figure 3. 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)** |