Prevalence and factors associated with childhood diarrheal disease and acute respiratory infection in Bangladesh: An analysis of a nationwide cross-sectional survey

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Prevalence and factors associated with childhood diarrheal disease and acute respiratory infection in Bangladesh: An analysis of a nationwide cross-sectional survey

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ABSTRACT

Objectives: This study aimed to estimate the prevalence of CDDs and ARIs and also to determine the factors associated with these conditions at the population level in Bangladesh.

Setting: The study entailed an analysis of nationally representative cross-sectional secondary data from the most recent Bangladesh Demography and Health Survey (BDHS) data conducted in 2017-2018.

Participants: A total of 7222 children < 5 years old for CDDs, and 7215 children aged below 5 years for ARIs during the survey from mothers aged between 15 to 49 years are the participants of this study.

Results: The overall prevalence of CDD and ARI among children < 5 years old were found to be 4.91% and 3.03%, respectively. Younger children were more likely to develop both CDDs and ARIs compared to their older counterparts. Children belonging to households classified as poorest (aOR=2.414, 95% CI (1.091 to 5.341)) and with unimproved floor materials (aOR=1.821, 95% CI (1.145 to 2.896)) had a higher prevalence of diarrhea than those from households identified as richest and with improved floor material, respectively. Stunted children had 40.8% higher odds of diarrhea than normal children (aOR=1.408, 95% CI (1.055 to 1.879)). Male children were 48.9% more likely to develop ARI than female children (aOR=1.489, 95% CI (1.132 to 1.960)). Children of mothers aged below 20 years had 2 times higher odds of ARI compared to children of mothers aged 20 to 34 years (aOR=2.166, 95% CI (1.403 to 3.344)). Children whose mothers had no formal education or had primary and secondary education had higher odds of ARI compared to children of mothers having higher education.

Conclusion: Programs targeting children aged below 23 months should be designed and emphasis should be given to addressing barriers to mother's education and household wealth to reduce CDDs and ARIs.

Keywords: Childhood diarrhea, Acute respiratory infection, Prevalence, BDHS, Bangladesh

Strengths and limitations of this study

- We used the most recent nationally representative data for this study which ensures that our findings are generalizable to children in Bangladesh.
- This study sounds scientific methodologies to assess the prevalence and analyze the associated factors concurrently for ARI and CDD, something which previous studies have not done. Therefore, this is a major contribution to ARI and CDD literature in Bangladesh.
- Nevertheless, the use of secondary data that was based on cross-sectional design limits the analysis and the causal relationship cannot be ascertained between the outcome and independent variables.
- The variables were self-reported by mothers thereby putting at risk of recall bias.
- All in all, the strengths of this study far outweigh the limitations and are relevant to understanding ARI and CDD within that Bangladesh context.

INTRODUCTION

Protecting the health and wellbeing of children is a crucial component of public health and global health targets. This is exemplified in the ended Millennium Development Goals (MDGs) and the fairly new Sustainable Development Goals (SDGs), especially SDG 3.2 which seeks to reduce under-five mortality to as low as 25 per 1000 live births by 2030[1]. Nonetheless, diarrhea and acute respiratory infection (ARI) remain a major cause of morbidity and mortality among children under-five worldwide[2], with diarrheal disease constituting about 9% of under-five mortality (UNICEF, 2016). Available evidence also indicates that ARI constitutes one-fifth of all under-five mortality[3].

The severity of diarrheal disease and ARI cannot be underrated. Beyond its association with childhood mortality, both diarrheal disease and ARI among children have been linked with many child health outcomes[4,5]. In the first two years of a child where the incidence of ARI and diarrheal diseases is highest, it impedes the physical growth and development of the child, which may later translate into further adverse health events later in their adult life, that is, if the child survives[6].

Contextualizing the study, it is important to note that Bangladesh was successful in achieving the MDGs, specifically target 4 by attaining a 74% decline in under-five deaths from 1990-2015[7].

However, the country remains among the top 15 countries with a high prevalence of childhood mortality attributable to ARI and diarrheal disease[7]. Furthermore, evidence from Bangladesh shows that about 39% of all pediatric hospital admissions and, between 40-60% of total pediatric outpatient department visits were as a result of ARI[8]. This situation calls the attention of researchers to investigate ARI and diarrheal disease among children from the Bangladesh context.

Existing body of literature from Ethiopia[9], Nepal[10], and Uganda[11] have found ARI and diarrheal disease among children to be associated with household socioeconomic status. Evidence from Vietnam[12] also shows that childhood ARI and diarrheal disease were associated with rural residency. Other studies conducted elsewhere have also posited that the sex of the child and access to safe drinking water[10], sanitation[13], level of maternal education and maternal age[11], complementary feeding practices[14], breastfeeding practices[15], waste disposal[9], and household cooking fuel[16] to be significantly associated with ARI and diarrheal disease among children.

Current evidence that has used nationally representative data to investigate ARI and diarrheal disease among children in Bangladesh is sparse. To the best of our knowledge, existing current evidence has not looked at ARI and diarrheal disease concurrently. For instance, the study by Sarker et al.[17] was limited to only childhood diarrheal disease (CDD) whereas study by Sultana et al.[7] was limited to ARI. Therefore, our study is the first current evidence using nationally representative data that investigates both childhood diarrheal disease and ARI in Bangladesh. Hence, the aim of this study is to investigate the prevalence of ARI and CDD, and determine the factors associated with these two childhood morbidities in Bangladesh. Our findings our timely and relevant in preparing Bangladesh to achieve SDG 3.2, and facilitate the country's exist from the top 15 countries with high prevalence of CDD. Knowing the prevalence of ARI and CDD will inform policy makers in their policy formulation and target setting. Moreover, identifying the factors associated with ARI and CDD is critical to developing need-based strategies to combat ARI and CDD in Bangladesh.

METHODS

Data, sampling design, and study population

In this study, the latest Bangladesh demographic and health survey (BDHS) data 2017-18 was used which is the eighth national survey conducted by the National Institute of Population Research and

Training (NIPORT) of Health Education and Family Welfare Division of the Ministry of Health and Family Welfare under Training, Research and Development operational plan of 4th HPNSP (Health Population and Nutrition Sector Program)[18]. The BDHS 2017-2018 is a nationally representative cross-sectional household survey data, covering all the 7 administrative divisions of Bangladesh. Two-stage stratified sampling was used where 675 (227 in urban areas and 448 in rural areas) enumeration areas (EAs) were selected with probability proportional to size at the first stage and then a systematic sample of 30 households was selected from each EAs which constitute a sample of approximately 20,250 households. Detailed sampling and data collection procedures were given in the final BDHS report 2017-2018[18]. In this survey, ever-married women aged 15 to 49 years were approached for an interview in order to collect information on reproductive health, child health, and nutritional status. This leads to a total sample of 8,402 living children aged under five years born to women living in these households. From these, missing cases were removed and replaced due to missing information leaving a sample size of 7222 for diarrheal disease and 7215 for acute respiratory infection (ARI) of children < 5 years old.

Variable specification

Outcome variable

The current study focuses on two binary outcome variables: childhood diarrheal disease ("1" indicated the occurrence of diarrhea for the indicated period and "0" indicated no occurrence) and acute respiratory infection of children < 5 years old ("1" indicated the experience of ARI for the indicated period and "0" indicated no experience). A child was considered to suffer from diarrhea if the mother or primary caretaker reported that the child had diarrhea either in the last 24 hours or within the last 2 weeks. In the survey, childhood diarrheal disease was determined if the children had three or more loose or watery stools per day, in the 2 weeks preceding the survey. Similarly, symptoms of ARI of children were identified by asking their mothers if their children were ill with cough, and/or short rapid breathing, and/or difficult breathing two weeks prior to the survey[18–20]. For analysis, we combined "Yes, last two weeks" and "Yes, last 24 hours" into "Yes" for both ARI and Diarrhea.

Independent variables

The exposure (explanatory variables) of the current study consisted of administrative division (Barisal, Chittagong, Dhaka, Khulna Mymensingh, Rajshahi, Rangpur, and Sylhet), Sex of child (male, and female), current age of child (in months), mothers' age (in years), educational qualification of the parent, occupation of parent, type of place of residence, number of household members, household wealth index, household access to television and refrigerator, household floor materials, type of cooking fuel, source of drinking water, type of toilet facilities, drugs for intestinal parasites in last 6 months, birth order and nutritional status of the children (wasting, stunting, and weight for age). Our variable selection was based on the previous studies[17,21,22] and available information in BDHS data 2017-18. Nutritional status was measured by three child growth standards including stunting, wasting, and weight for age proposed by the World Health Organization (WHO). A child was said to be stunted whose height-for-age Z-score is < -2 standard deviation (-2SD) from the median. Similarly, A child was said to be wasted and underweighted whose weight for height Z- score and weight for age Z-score is < -2 standard deviation (-2SD) from the median, respectively[23]. Both mother's occupation and father's occupation was categorized as "Home maker/ No formal occupation (Not working, unemployed, student, retired)", "Poultry/Farming/Cultivator (land owner, farmer, agricultural worker, fisherman, poultry raising, cattle raising, home-based handicraft)", and "Professional" (Professional/Big business/Technical, Small business/semi-skilled & unskilled)[17].

The source of drinking water was categorized as "Improved (piped into dwelling, piped to yard/plot, public tap/standpipe, piped to neighbor, tube well or borehole, protected well, protected spring, rainwater, tanker truck, cart with small tank, bottled water)" and "Unimproved (unprotected well, unprotected spring, surface water (river/dam/lake/pond/stream/canal/irrigation channel, and other)" for the current study[24,25]. Type of toilet facilities was recategorized into "Improved (flush - to piped sewer system, flush - to septic tank, flush - to pit latrine, flush - don't know where, pit latrine - ventilated improved pit (VIP), pit latrine - with slab, composting toilet)" and "Unimproved (flush - to somewhere else, pit latrine - without slab / open pit, bucket toilet, hanging toilet/latrine, others)"[19]. Children under age of five years are the respondents of the current study whose ages were categorized into 5 categories (<12 months, 12-23 months, 24-35 months, 36-47 months, 48-59 months). Mother's age was coded as below 20 years, 20 to 34 years, and above 34 years[17]. Father's and mother's education had four categories no education, primary, secondary and higher education. Type of cooking fuel used was recategorized into "Clean fuel (electricity, liquefied petroleum gas (LPG), natural gas, and biogas)" and "Polluted fuel (coal/lignite, charcoal, wood, straw/shrub/grass, agricultural crops, and animal dung)"[26]. Birth order of the respondent was categorized as first child, second child and third and above. The household wealth index is a measure of living standard. DHS calculated household wealth index using Principal component analysis (PCA) based on household's ownership of selected assets, such as televisions and bicycles; materials used for housing construction; and types of water access and sanitation facilities which had five wealth quintiles (poorest, poorer, middle, richer, richest)[27]. Family size or number of household family members were divided into two categories (≤ five members and > five members). Floor materials were categorized into "Improved (cement, ceramic tiles, vinyl asphalt strips, parquet, polished wood)" and "Unimproved (earth, sand, dung, wood planks, palm, bamboo)"[28].

Data processing and analysis

Data management and analyses were done using SPSS version 25.0, and R version 4.0.1 for the children's data set (KR file). Descriptive weighted prevalence was computed to show the prevalence of diarrhea and ARI among children under 5 years of age accounting the stratification and sampling weights. The weights were obtained from the women's individual sample weight dividing by 1000000. Frequencies and category-based percentages were showed to present the descriptive characteristics of study participants. Chi-square test was performed to identify the association between considered risk factors and Diarrhea as well as ARI. Binary logistic regression was carried out to assess the adjusted and crude effect of risk factors on diarrhea and ARI among children of age under five years. Adjusted odds ratio (AOR) and crude odds ratio (OR) with 95% CI were performed in the analysis of the current study. A p value of less than 0.05 was considered to be statistically significant.

Patient and public involvement

No patient involved

RESULTS

Background characteristics

After data cleaning, a total of 7222 mothers having children <5 years old were included in case of diarrheal disease, and 7215 mothers who had children <5 years were included in case of ARI in the present study. The age of the children was categorized with an 11 months interval and was almost equally distributed for the age category. More than half of the mothers were home maker who had no formal occupation. Most of the children (64.8%) in the study were from the rural area.

Considering the measurement of nutritional statuses, 30.2%, 22.4%, and 8.2% of children were identified to be stunted, underweight, and wasted, respectively. Most of the households had an improved toilet facility (68.2%), and an improved source of drinking water (97.7%) **(Table 1 & 2)**.

Table 1: Demographic characteristics and distribution of prevalence of childhood diarrheal disease (N = 7222)

Variables	Categories	Weighted prevalence (%)	Total; n (%)	Had diarrhea Yes; n (%)	p value
Region	Barisal	6.78	732 (10.1)	50 (6.8)	0.139
	Chittagong	5.54	1147 (15.9)	64 (5.6)	
	Dhaka	3.81	1089 (15.1)	42 (3.9)	
	Khulna	4.08	758 (10.5)	32 (4.2)	
	Mymensingh	5.14	872 (12.1)	46 (5.3)	
	Rajshahi	5.93	745 (10.3)	44 (5.9)	
	Rangpur	4.92	810 (11.2)	38 (4.7)	
	Sylhet	4.89	1069 (14.8)	56 (5.2)	
Sex of child	Male	5.23	3780 (52.3)	212 (5.6)	0.065
	Female	4.56	3442 (47.7)	160 (4.6)	
Current age of child	<12 months	5.92	1453 (20.1)	95 (6.5)	**0.000**
	12-23 months	9.36	1441 (20.0)	139 (9.6)	
	24-35 months	5.39	1432 (19.8)	77 (5.4)	
	36-47 months	2.40	1375 (19.0)	36 (2.6)	
	48-59 months	1.43	1521 (21.1)	25 (1.6)	
Mothers' age in years	Below 20	4.89	5776 (80.0)	299 (5.2)	**0.013**
	20-34	6.50	806 (11.2)	53 (14.2)	
	Above 34	2.91	640 (8.9)	20 (3.1)	
Educational level of mothers	No education	6.28	548 (7.6)	31 (5.7)	0.956
	Primary	4.61	2131 (29.5)	108 (5.1)	
	Secondary	4.87	3378 (46.8)	173 (5.1)	
	Higher	4.92	1165 (16.1)	60 (5.2)	
Education level of fathers	No education	4.08	1110 (15.4)	45 (4.1)	0.244
	Primary	5.64	2575 (35.7)	146 (5.7)	
	Secondary	4.68	2255 (31.2)	116 (5.1)	
	Higher	4.53	1282 (17.8)	65 (5.1)	
Mother's occupation	Home maker/No formal occupation	5.38	3988 (55.2)	224 (5.6)	0.124
	Poultry/Farming/Cultivator	4.19	2330 (32.3)	104 (4.5)	
	Professional	4.70	904 (12.5)	44 (4.9)	
Father's occupation	Home maker/No formal occupation	1.11	60 (0.8)	1 (1.7)	0.103
	Poultry/Farming/Cultivator	4.33	1491 (20.6)	64 (4.3)	
	Professional	5.11	5671 (78.5)	307 (5.4)	
Type of place of residence	Urban	4.62	2543 (35.2)	132 (5.2)	0.910
	Rural	5.02	4679 (64.8)	240 (5.1)	
Number of household members	≤ 5 members	4.81	4108 (56.9)	210 (5.1)	0.863
	> 5 members	5.05	3114 (43.1)	162 (5.2)	
Wealth index	Poorest	6.52	1253 (17.3)	84 (6.7)	**0.022**
	Poorer	5.11	1474 (20.4)	80 (5.4)	
	Middle	5.07	1620 (22.4)	82 (5.1)	
	Richer	4.74	1428 (19.8)	70 (4.9)	

	Richest	3.24	1447 (20.0)	56 (3.9)	
Household has: television	No	4.93	3789 (52.5)	195 (5.1)	0.986
	Yes	4.89	3433 (47.5)	177 (5.2)	
Household has: refrigerator	No	4.94	5009 (69.4)	258 (5.2)	0.999
	Yes	4.85	2213 (30.6)	114 (5.2)	
Floor materials	Improved	4.04	2666 (36.9)	120 (4.5)	0.056
	Unimproved	5.40	4556 (63.1)	252 (5.5)	
Type of cooking fuel	Clean fuel	4.08	1493 (20.7)	70 (4.7)	0.393
	Polluted fuel	5.14	5729 (79.3)	302 (5.3)	
Source of drinking water	Improved	4.96	7059 (97.7)	368 (5.2)	0.115
	Unimproved	2.48	163 (2.3)	4 (2.5)	
Type of toilet facilities	Improved	4.84	4926 (68.2)	252 (5.1)	0.843
	Unimproved	5.07	2296 (31.8)	120 (5.2)	
Drugs for intestinal parasites in last 6 months	No	5.37	4219 (58.4)	241 (5.7)	**0.011**
	Yes	4.27	3003 (41.6)	131 (4.4)	
Birth order	First child	5.07	2590 (35.9)	137 (5.3)	0.429
	Second child	5.27	2359 (32.7)	129 (5.5)	
	Third and so	4.35	2273 (31.5)	106 (4.7)	
Stunting status	Normal	5.01	5044 (69.8)	269 (5.3)	0.287
	Stunted	4.66	2178 (30.2)	103 (4.7)	
Weight for age	Normal	4.77	5603 (77.6)	287 (5.1)	0.838
	Underweight	5.41	1619 (22.4)	85 (5.3)	
Wasting status	Normal	4.84	6631 (91.8)	341 (5.1)	0.914
	Wasted	5.77	591 (8.2)	31 (5.2)	
Total		4.91	7222 (100)	372 (5.2)	

The bolded p values indicate the statistical significance

The results and the associated χ^2 tests shown in **Table 1** indicate that the incidence of childhood diarrheal disease in Bangladesh is significantly associated with the age of children, mothers' age, household wealth index, and drug intake for intestinal parasites. The associated χ^2 tests regarding ARI of children in Bangladesh shown in **Table 2** reveal that region, age and sex of children, mothers' age, and household having television and refrigerator were significantly associated with ARI.

Prevalence of diarrheal disease and ARI

The overall prevalence of diarrheal disease among children < 5 years old was 4.91%. The highest diarrheal prevalence was found among children from Barisal region (6.78%), followed by Rajshahi region (5.93%) **(Figure 1)**. Among the age groups, children aged between 12 to 23 months (9.36%) were most vulnerable to diarrhea, followed by <12 months old children (5.92%). Children of young mothers aged between 20 to 34 years old suffered from diarrhea more (6.50%) than those of older mothers aged above 34 years old (2.91%). Children of mothers with no formal education (6.28%) were found to be more vulnerable to diarrheal disease. Based on the five quintiles of the household wealth index, the diarrheal prevalence was higher among children from the poorest families (6.52%). A high prevalence was observed in children (5.37% vs 4.27%) who did not intake drugs for intestinal parasites in the last 6 months prior to data collection, and who were stunted (5.01% vs 4.66%). A high prevalence was observed in households that had unimproved floor materials (5.40% vs 4.04%) **(Table 1)**.

The overall prevalence of ARI among children < 5 years old was 3.03%. The highest prevalence of ARI observed in Rangpur region (5.47%), followed by Barishal (4.11%) region of Bangladesh **(Figure 2)**. Children aged between 12 to 23 months (4.10%) were found to be more vulnerable to ARI, followed by <12 months old children (4.07%). A higher prevalence of ARI was found among children of mothers aged 20 to 34 years (5.28%). ARI prevalence was higher among male (3.63%) than female children (2.36%). The prevalence of ARI is highest (3.56%) among the children whose mothers had no formal education, and a similar pattern was also observed with the educational status of fathers. Based on the socioeconomic status of the households, ARI prevalence was higher (3.98%) in the households with lower socioeconomic status **(Table 2)**.

Table 2: Demographic characteristics and distribution of prevalence of ARI (N = 7215)

Variables	Categories	Weighted prevalence (%)	Total; n (%)	Had ARI Yes; n (%)	p value
Region	Barisal	4.11	730 (10.1)	30 (4.1)	**0.001**
	Chittagong	2.82	1145 (15.9)	31 (2.7)	
	Dhaka	2.12	1089 (15.1)	23 (2.1)	
	Khulna	1.89	758 (10.5)	15 (2.0)	
	Mymensingh	2.53	872 (12.1)	22 (2.5)	
	Rajshahi	3.91	744 (10.3)	27 (3.6)	
	Rangpur	5.47	810 (11.2)	43 (5.3)	
	Sylhet	3.10	1067 (14.8)	35 (3.3)	
Sex of child	Male	3.63	3778 (52.4)	138 (3.7)	**0.008**
	Female	2.36	3437 (47.6)	88 (2.6)	
Current age of child	<12 months	4.07	1452 (20.1)	65 (4.5)	**<0.001**
	12-23 months	4.10	1439 (19.9)	61 (4.2)	
	24-35 months	2.13	1429 (19.8)	30 (2.1)	
	36-47 months	2.81	1374 (19.0)	37 (2.7)	
	48-59 months	2.03	1521 (21.1)	33 (2.2)	
Mothers' age in years	Below 20 years	2.70	806 (11.2)	44 (5.5)	**<0.001**
	20-34 years	5.28	5769 (80.0)	163 (2.8)	
	Above 34 years	2.93	640 (8.9)	44 (5.5)	
Educational level of mothers	No education	3.56	547 (7.6)	19 (3.5)	0.085
	Primary	3.22	2130 (29.5)	70 (3.3)	
	Secondary	2.16	3374 (46.8)	88 (2.6)	
	Higher	1.40	1164 (16.1)	18 (1.6)	
Education level of fathers	No education	3.56	1110 (15.4)	40 (3.6)	0.177
	Primary	3.24	2573 (35.7)	85 (3.3)	
	Secondary	3.15	2251 (31.2)	73 (3.2)	

	Higher	1.82	1281 (17.8)	28 (2.2)	
Mother's occupation	Home maker/No formal occupation	2.53	3982 (55.2)	109 (2.7)	0.089
	Poultry/Farming/Cultivator	3.59	2329 (32.3)	82 (3.5)	
	Professional	3.74	904 (12.5)	35 (3.5)	
Father's occupation	Home maker/No formal occupation	0.0	60 (0.8)	0 (0.0)	0.190
	Poultry/Farming/Cultivator	3.63	1488 (20.6)	54 (3.6)	
	Professional	2.89	5495 (78.5)	172 (3.0)	
Type of place of residence	Urban	2.74	2541 (35.2)	77 (3.0)	0.714
	Rural	3.14	4674 (64.8)	149 (3.2)	
Number of household members	≤ 5 members	2.90	4105 (56.9)	127 (3.1)	0.829
	> 5 members	3.20	3110 (43.1)	99 (3.2)	
Wealth index	Poorest	3.98	1618 (22.4)	61 (3.8)	0.166
	Poorer	3.35	1429 (19.8)	49 (3.4)	
	Middle	2.72	1251 (17.3)	38 (3.0)	
	Richer	3.03	1444 (20.0)	45 (3.1)	
	Richest	1.90	1473 (20.4)	33 (2.2)	
Household has: television	No	3.63	3786 (52.5)	137 (3.6)	**0.013**
	Yes	2.37	3429 (47.5)	89 (2.6)	
Household has: refrigerator	No	3.38	5004 (69.4)	172 (3.4)	**0.025**
	Yes	2.22	2211 (30.6)	54 (2.4)	
Floor materials	Improved	2.49	2662 (36.9)	76 (2.9)	0.301
	Unimproved	3.33	4553 (63.1)	150 (3.3)	
Type of cooking fuel	Clean fuel	2.16	1492 (20.7)	36 (2.4)	0.073
	Polluted fuel	3.26	5723 (79.3)	190 (3.3)	
Birth order	First child	2.89	2588 (35.9)	73 (2.8)	0.460
	Second child	2.65	2358 (32.7)	81 (3.4)	
	Third and so	3.40	2269 (31.4)	72 (3.2)	
Stunting status	Normal	3.06	5039 (69.8)	153 (3.0)	0.476
	Stunted	2.90	2176 (30.2)	73 (3.4)	
Weight for age	Normal	3.32	5597 (77.6)	176 (3.1)	0.912
	Underweight	3.03	1618 (22.4)	50 (3.1)	
Wasting status	Normal	3.03	6624 (91.8)	204 (3.1)	0.390
	Wasted	2.99	591 (8.2)	22 (3.7)	
Total		3.03	7215 (100)	226 (3.1)	

The bolded p values indicate the statistical significance

Factors associated with childhood diarrheal disease

Table 3 shows the factors influencing the diarrheal prevalence of children under five years old in Bangladesh. Both bivariate (unadjusted) and multivariate (adjusted) logistic regression analyses were done, where multivariate logistics regression was employed to control for possible confounding effects. The adjusted model shows that male children were 22.4% more likely to experience diarrhea, compared to female children (adjusted Odd Ratio [aOR] = 1.224, 95% Confidence Interval [CI] = 1.02, 1.517). The diarrheal disease was significantly associated with the age of the children: below 12 to 23 months old children (aOR = 6.775, 95% CI = 4.346, 10.561) were at the highest risk to develop diarrhea, followed by those below 12 months old (aOR = 4.272, 95% CI = 2.647, 6.892), compared to the children aged 58 to 59 months. Children aged 24 to 35 months old showed 3.467 times higher odds of experiencing diarrheal disease compared to their older counterparts (aOR = 3.467, 95% CI = 2.187, 5.499). We also found a statistically significant association between childhood diarrheal disease and household wealth index. Children belonging to the poorest household wealth index category were 2.414 times more likely to develop diarrhea, compared to the children from the richest households (aOR = 2.414, 95% CI = 1.091, 5.341). Children from households with unimproved floor materials were 82.1% more likely to have diarrhea than those from households with improved floor materials (aOR = 1.821, 95% CI = 1.145, 2.896). It was also found that stunted children were 40.8% more prone to have diarrhea than those who were normal (aOR = 1.408, 95% CI = 1.055, 1.879). It was also found that children from Barisal region (aOR = 1.861, 95% CI = 1.181, 2.932) were most diarrhea prone, followed by Rajshahi region (aOR = 1.636, 95% CI = 1.029, 2.602) than those in Dhaka region **(Table 3)**.

Table 3: Binary logistic regression analysis of factors associated with childhood diarrhea

Variables	Categories	Unadjusted		Adjusted	
		OR	95% CI	OR	95% CI
Region (Ref: Dhaka)	Chittagong	1.473	(0.989, 2.194)	1.472	(0.971, 2.233)
	Barisal	**1.828****	(1.199, 2.785)	**1.861****	(1.181, 2.932)
	Khulna	1.099	(0.687, 1.757)	1.210	(0.735, 1.991)
	Mymensingh	1.388	(0.905, 2.130)	1.461	(0.923, 2.314)
	Rajshahi	**1.565***	(1.014, 2.414)	**1.636***	(1.029, 2.602)
	Rangpur	1.227	(0.784, 1.922)	1.323	(0.814, 2.150)
	Sylhet	1.378	(0.915, 2.075)	1.468	(0.951, 2.266)
Sex of child (ref: female)	Male	1.219	(0.987, 1.505)	**1.224***	(1.02, 1.517)
Current age of child (Ref: 48-59 months)	<12 months	**4.186*****	(2.678, 6.543)	**4.272*****	(2.647, 6.892)
	12-23 months	**6.388*****	(4.147, 9.843)	**6.775*****	(4.346, 10.561)
	24-35 months	**3.401*****	(2.153, 5.371)	**3.467*****	(2.187, 5.499)
	36-47 months	1.609	(0.961, 2.694)	1.646	(0.981, 2.762)
Mothers' age in years (Ref: 20-34)	Below 20	1.289	(0.953, 1.744)	0.933	(0.653, 1.334)
	Above 34	0.591	(0.373, 0.936)	0.696	(0.426, 1.140)
Educational level of mothers (Ref: Higher)	No education	1.104	(0.707, 1.725)	0.709	(0.460, 1.093)
	Primary	0.983	(0.711, 1.359)	**0.628***	(0.401, 0.984)
	Secondary	0.994	(0.735, 1.344)	0.570	(0.322, 1.006)
Education level of fathers (Ref: No education)	Primary	**1.423***	(1.011, 2.002)	0.859	(0.519, 1.424)
	Secondary	1.283	(0.903, 1.825)	1.161	(0.776, 1.737)
	Higher	1.264	(0.857, 1.865)	1.035	(0.714, 1.499)
Mother's occupation (ref: Home maker/No formal occupation)	Poultry/Farming/ Cultivator	**0.785***	(0.619, 0.996)	0.851	(0.651, 1.113)
	Professional	0.860	(0.617, 1.198)	1.036	(0.733, 1.464)
Father's occupation (ref: Home maker/No formal occupation)	Poultry/Farming/ Cultivator	2.646	(0.36, 19.402)	2.815	(0.376, 21.100)
	Professional	3.377	(0.466, 24.45)	3.270	(0.443, 24.117)

Type of place of residence (ref: Urban)	Rural	0.988	(0.794, 1.228)	0.912	(0.701, 1.186)
Number of household members (ref: ≤ 5 members)	> 5 members	1.019	(0.825, 1.257)	0.946	(0.755, 1.186)
Wealth index (ref: Richest)	Poorest	1.076	(0.784, 1.477)	**2.414***	(1.091, 5.341)
	Poorer	1.348	(0.985, 1.844)	1.448	(0.975, 2.152)
	Middle	0.967	(0.697, 1.341)	0.982	(0.693, 1.391)
	Richer	0.755	(0.533, 1.069)	1.194	(0.667, 2.138)
Household has: television (ref: No)	Yes	1.002	(0.813, 1.235)	0.969	(0.731, 1.284)
Household has: refrigerator (ref: No)	Yes	1.000	(0.798, 1.254)	0.951	(0.678, 1.333)
Floor materials (ref: Improved)	Unimproved	1.242	(0.994, 1.552)	**1.821***	(1.145, 2.896)
Type of cooking fuel (ref: Clean fuel)	Polluted fuel	1.131	(0.867, 1.477)	1.207	(0.826, 1.763)
Source of drinking water (ref: Improved)	Unimproved	0.457	(0.169, 1.241)	0.477	(0.173, 1.317)
Type of toilet facilities (ref: Improved)	Unimproved	1.023	(0.818, 1.279)	0.979	(0.746, 1.287)
Drugs for intestinal parasites in last 6 months (ref: No)	Yes	**0.753***	(0.605, 0.936)	1.053	(0.818, 1.355)
Birth order (ref: First child)	Second child	1.036	(0.809, 1.136)	1.009	(0.762, 1.335)
	Third and so	0.876	(0.675, 1.136)	0.872	(0.631, 1.206)
Stunting status (ref: Normal)	Stunted	0.881	(0.698, 1.112)	**1.408***	(1.055, 1.879)
Weight for age (ref: Normal)	Underweight	1.026	(0.800, 1.316)	1.340	(0.968, 1.856)
Wasting status (ref: Normal)	Wasted	1.021	(0.700, 1.490)	0.896	(0.590, 1.363)

The bolded values (ORs) indicate the statistical significance.
*p < 0.05; **p < 0.01; ***p < 0.001; OR = Odd Ratio; CI = Confidence Interval.

Factors associated with ARI of children

Our multivariate regression analysis on ARI revealed that children aged <12 months (aOR = 1.883, 95% CI = 1.206, 2.939) and 12 – 23 months (aOR = 1.780, 95% CI = 1.141, 2.776) had 88.3% and 78%, respectively, higher prevalence of ARI compared to children aged 48 – 59 months old. In the present study, male children were 48.9% more likely to have ARI than female children (aOR = 1.489, 95% CI = 1.132, 1.960). Children of mothers aged < 20 years had two times higher odds of having ARI compared to those of mothers aged between 20 – 34 years (aOR = 2.166, 95% CI = 1.403, 3.344). we also found that the educational qualification of mothers had a great influence on ARI of children. Children of mothers having no formal education (aOR = 2.331, 95% CI = 1.139, 4.771), primary education (aOR = 2.488, 95% CI = 1.190, 5.202), and secondary education (aOR = 2.654, 95% CI = 1.102, 6.392) had higher prevalence of ARI compared to those whose mothers had above secondary or higher education. Children of professional mothers were 68.4% more likely to have ARI compared to those of mothers who were home maker or had no formal occupation (aOR = 1.684, 95% CI = 1.121, 2.53). Similar to the diarrheal prevalence, geographical location was one of the emergent influential factors for ARI of children. From the distribution of ARI cases, it was found that children who lived in Rangpur region (aOR = 2.710, 95% CI = 1.474, 4.982) were most diarrhea prone, followed by Barisal region (aOR = 2.143, 95% CI = 1.127,4.077). In addition, children from Sylhet region were 93.2% more likely to develop ARI, compared to those from Khulna region (aOR = 1.932, 95% CI = 1.021, 3.653) **(Table 4).**

Table 4: Binary logistic regression analysis of factors associated with ARI of children

Variables	**Categories**	**Unadjusted**		**Adjusted**	
		OR	**95% CI**	**OR**	**95% CI**
Region (ref: Khulna)	Barisal	**2.123***	(1.133, 3.979)	**2.143***	(1.127,4.077)
	Chittagong	1.378	(0.739, 2.571)	1.454	(0.767, 2.754)
	Dhaka	1.069	(0.554, 2.062)	1.163	(0.584, 2.318)
	Sylhet	1.680	(0.911, 3.098)	**1.932***	(1.021, 3.653)
	Mymensingh	1.282	(0.660, 2.489)	1.322	(0.673, 2.596)
	Rajshahi	1.865	(0.984, 3.536)	1.851	(0.971, 3.528)
	Rangpur	**2.777****	(1.530, 5.041)	**2.710****	(1.474, 4.982)
Sex of child (ref: female)	Male	**1.443****	(1.100, 1.893)	**1.489****	(1.132, 1.960)
Current age of child (ref: 48-59 months)	<12 months	**2.113****	(1.381, 3.233)	**1.883****	(1.206, 2.939)
	12-23 months	**1.996****	(1.299, 3.068)	**1.780***	(1.141, 2.776)
	24-35 months	0.967	(0.587, 1.594)	0.900	(0.542, 1.496)
	36-47 months	1.248	(0.776, 2.007)	1.226	(0.759, 1.979)
Mothers' age in years (ref: 20-34 years)	Below 20 years	**1.986*****	(1.411, 2.794)	**2.166*****	(1.403, 3.344)
	Above 34 years	1.052	(0.650, 1.704)	1.095	(0.649, 1.847)
Educational level of mothers (ref: Higher)	No education	**2.182***	(1.086, 4.384)	**2.331***	(1.139, 4.771)
	Primary	**2.052***	(1.034, 4.072)	**2.488***	(1.190, 5.202)
	Secondary	1.581	(0.746, 3.354)	**2.654***	(1.102, 6.392)
Education level of fathers (ref: Higher)	No education	**1.673***	(1.025, 2.730)	1.816	(0.961, 3.433)
	Primary	1.529	(0.992, 2.356)	1.471	(0.840, 2.578)
	Secondary	1.500	(0.965, 2.332)	1.495	(0.888, 2.518)
Mother's occupation (ref: Home maker/No formal occupation)	Poultry/Farming/ Cultivator	1.297	(0.969, 1.735)	1.184	(0.852, 1.643)
	Professional	1.431	(0.971, 2.109)	**1.684***	(1.121, 2.53)
Father's occupation (ref: Professional)	No formal occupation	0.0	(0.0, 0.0)	0.0	(0.0, 0.0)
	Poultry/Farming/ Cultivator	1.203	(0.881, 1.642)	1.094	(0.777, 1.540)
Type of place of residence (ref: Urban)	Rural	1.054	(0.797, 1.393)	0.866	(0.620, 1.210)
Number of household members (ref: ≤ 5 members)	> 5 members	1.030	(0.789, 1.435)	1.021	(0.768, 1.358)
Wealth index (ref: Richest)	Poorest	**1.710***	(1.113, 2.627)	1.439	(0.524, 3.951)
	Poorer	1.549	(0.990, 2.424)	1.459	(0.548, 3.886)
	Middle	1.367	(0.852, 2.193)	1.384	(0.593, 3.229)
	Richer	1.404	(0.890, 2.213)	1.186	(0.664, 2.119)
Household has: television (ref: No)	Yes	0.710	(0.541, 0.931)	0.803	(0.561, 1.150)
Household has: refrigerator (ref: No)	Yes	**0.703***	(0.516, 0.959)	1.039	(0.659, 1.639)
Floor materials (ref: Improved)	Unimproved	1.159	(0.876, 1.534)	0.653	(0.366, 1.164)
Type of cooking fuel (ref: Clean fuel)	Polluted fuel	1.389	(0.968-1.992)	1.098	(0.661, 1.823)
Birth order (ref: Third and so)	First child	0.886	(0.636, 1.233)	0.705	(0.457, 1.088)
	Second child	1.085	(0.786, 1.499)	1.076	(0.754, 1.535)
Stunting status (ref: Stunted)	Normal	0.902	(0.679, 1.198)	0.896	(0.637, 1.260)

Weight for age (ref: Underweight)	Normal	1.018	(0.740, 1.401)	1.119	(0.746, 1.679)
Wasting status (ref: Wasted)	Normal	0.822	(0.525, 1.286)	0.797	(0.486, 1.306)

The bolded values (ORs) indicate the statistical significance.
*p < 0.05; **p < 0.01; ***p < 0.001; OR = Odd Ratio; CI = Confidence Interval.

DISCUSSION

Although Bangladesh met the MDG targets, it still remains among the top 15 countries with high cases of CDD and ARI[7]. Therefore, to ensure that there is a greater understanding of the situation of ARI and CDD in Bangladesh, as well as facilitate its potential to achieve SDG 3.2, we investigated the prevalence of ARI and CDD, and determined the factors that are associated with these two childhood health events. Our study indicates that the prevalence of CDD and ARI was 4.91% and 3.03% respectively, with the prevalence for both outcomes being highest for children born to younger mothers (20-34 years), mothers with no formal education, those in lower socioeconomic status. The ARI prevalence observed reflects a trend of decline in the prevalence of ARI from previous rounds of the BDHS survey reports[7,29,30].

Concerning the factors associated with ARI and CDD, the results of our study show that it was significantly associated with the sex of the child, with male children being at higher risk of ARI or CDD. This finding is in line with earlier studies from Bangladesh[7], Ethiopia[14], Nepal[10], Sudan[31], and Thailand[32] that have reported higher risk of ARI and CDD among male children. This could probably be due to differences in genetics that places males at higher risk of diseases and other health events compared to women[7]. Another plausible explanation could be due to higher reporting for male children, which is reinforced by mothers' preference for the male child[33]. As such, they are able to notice changes in the health status of the male child early and report to the hospital accordingly.

There is a myriad of evidence suggesting that ARI and CDD are most prevalent in the first two years of a child's life, thus, making children <12 months and those between 12-23 months being at higher risk of ARI or CDD[13,17,34]. Our finding provides confirmation of this association. Moreover, the finding from this study indicates that although the prevalence of ARI and CDD is higher within the first two years of a child's life, the risk of developing ARI or CDD is highest in children between 12-23 months, which supports Sarker et al.[17] findings that the prevalence of CDD is highest for children aged 1 to 2 years compared to those less than a year old. However, our findings that younger child age is associated with higher prevalence and risk of ARI and CDD could be explained from the point that, the immune system of the child is delicate at that early age, thereby putting them at increased risk of infections[35]. Furthermore, children which such early years tend to be heavily dependent on their mothers and therefore, require appropriate feeding that is proportional to their age[17]. Hence, when mothers slack in their responsibilities to provide safe and appropriate feeding to the children at that age, then their risk of ARI and CDD increases.

We found a significant association between household wealth status and risk of CDD, with children belonging to the poorest household having greater likelihood of developing the diarrheal disease. This corroborates previous related studies from Bangladesh[16,17] and Nepal[10] that also reported higher risk of CDD among children belonging to poor households. This may possibly be justified from the perspective that; poorer households have difficulty in meeting their nutritional needs and adopting appropriate feeding practices which may exacerbate their risk of diarrheal infection[10]. This is further iterated in our finding that stunted children had a higher risk of CDD.

Congruent to existing literature[3,11], our study indicates that there is significant association between formal education and ARI, with lower odds of ARI being reported among children whose mothers had formal education compared to those whose mothers had no formal education. A plausible justification for this finding could be that children spend more time with their mothers; therefore, the mother's educational attainment will reflect in the quality of care that they will provide to their child, which may either increase the risk or protection against ARI[36]. Hence, emphasizing the need to promote formal education among women.

Beyond these individual and household factors, we found statistically significant association between geographical region and the risks of ARI and CDD. It was found that children who lived in Rangpur region and Barisal region were at higher risk of developing ARI or CDD. This is consistent with previous studies from Bangladesh[17] that also found similar findings in relation to the regional differences in the prevalence of ARI and CDD. Begum and her colleagues also reported a higher diarrheal prevalence among children < 5 years old in the similar setting and found that water, sanitation and hygiene (WASH) education to the mothers was effective to reduce the burden of diarrhea [37]. According to Sarker et al[17], regions like Barisal are densely populated and is also characterized by the existence of more rivers and water reservoirs that create an enabling environment for diarrheal disease to spread among the population. Perhaps, this could be the reason for the high prevalence of ARI and CDD within the Barisal region.

CONCLUSION

Bangladesh met the MDG targets but still remains among the top 15 countries with high cases of CDD and ARI. This study sought to investigate the prevalence of ARI and CDD, and determine the associated factors. Based on the findings from the study, we conclude that the prevalence of ARI and CDD in Bangladesh has reduced when compared with previous studies and previous rounds of the BDHS. We also conclude that there are individual, household and geographic factors that exacerbate the risk of ARI and CDD (children born to mothers of younger age, mothers with no formal education, belonging to lower socioeconomic households, being a male child, being stunted, and residing in Barisal and Rangpur regions). Therefore, we recommend that the government of Bangladesh commit resources, policies and interventions geared towards ARI and CDD reduction to the identified at-risk groups. Also, there is the need to augment formal education for women in Bangladesh to accelerate the realization of SDG 3.2, and complete eradication of ARI and CDD in the country. Further studies can be conducted to explore how culture also permeates the dynamics of ARI and CDD in Bangladesh, in order to ensure that interventions and policies developed are culturally sensitive to facilitate acceptance and adherence.

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Author contributions

Satyajit Kundu: Conceptualization, methodology, data curation, formal analysis, writing - original draft, final approval; **Subarna Kundu:** Conceptualization, methodology, data curation, formal analysis, writing - original draft, final approval; **Md. Hasan Al Banna**: Writing - original draft; **Bright Opoku Ahinkorah**: Writing - original draft, review and editing, final approval; **Abdul-Aziz Seidu**: Writing - original draft, review and editing; **Joshua Okyere**: Writing - original draft, review and editing.

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Patient consent for publication

Not required.

Ethics approval

The current study used publicly available secondary data provided by Bangladesh demographic and health survey (BDHS) which is collected by following standardized data collection procedures. Procedures and questionnaires for standard DHS surveys have been ethically reviewed and approved by ICF Institutional Review Board (IRB), Maryland, USA. The data is downloaded from the demographic and health survey website for research purposes. Written informed consent from the respondents enrolled in the survey and other ethical review documents are available at: https://dhsprogram.com/methodology/Protecting-the-Privacy-of-DHS-Survey-Respondents.cfm. The data set is available online publicly for all researchers, hence there is no need to approve.

Data sharing statement

The study used data from the 2017-2018 Bangladesh Demographic and Health Survey. The data set is available at: https://dhsprogram.com/data/available-datasets.cfm

REFERENCES

1 Apanga PA, Kumbeni MT. Factors associated with diarrhoea and acute respiratory infection in children under-5 years old in Ghana: an analysis of a national cross-sectional survey. BMC Pediatr 2021;21:1–8.

2 WHO. WHO Global Health Observatory (GHO) data. Causes of child mortality 2015. 2015.

3 Pinzón-Rondón ÁM, Aguilera-Otalvaro P, Zárate-Ardila C, et al. Acute respiratory infection in children from developing nations: a multi-level study. Paediatr Int Child Health 2016;:1–7.

4 Nasanen-Gilmore SPK, Saha S, Rasul I, et al. Household environment and behavioral

determinants of respiratory tract infection in infants and young children in northern Bangladesh. Am J Hum Biol 2015;27:851–8.

5 WHO. Ending preventable child deaths from pneumonia and diarrhoea by 2025: the integrated Global Action Plan for Pneumonia and Diarrhoea (GAPPD). 2013.

6 Dewey KG, Mayers DR. Early child growth: how do nutrition and infection interact? Matern Child Nutr 2011;7:129–42.

7 Sultana M, Sarker AR, Sheikh N, et al. Prevalence, determinants and health care-seeking behavior of childhood acute respiratory tract infections in Bangladesh. PLoS One 2019;14:e0210433.

8 Kabir AL, Amin MR, Mollah MAH, et al. Respiratory disorders in under-five children attending different hospitals of Bangladesh: A cross sectional survey. J Respir Med Res Treat 2016;11:2016–183615.

9 Gebru T, Taha M, Kassahun W. Risk factors of diarrhoeal disease in under-five children among health extension model and non-model families in Sheko district rural community, Southwest Ethiopia: comparative cross-sectional study. BMC Public Health 2014;14:1–6.

10 Budhathoki SS, Bhattachan M, Yadav AK, et al. Eco-social and behavioural determinants of diarrhoea in under-five children of Nepal: a framework analysis of the existing literature. Trop Med Health 2016;44:1–7.

11 Bbaale E. Determinants of diarrhoea and acute respiratory infection among under-fives in Uganda. Australas Med J 2011;4:400.

12 Lee H-Y, Huy N Van, Choi S. Determinants of early childhood morbidity and proper treatment responses in Vietnam: results from the Multiple Indicator Cluster Surveys, 2000–2011. Glob Health Action 2016;9:29304.

13 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 J Prev Med 2013;3:446.

14 Anteneh ZA, Andargie K, Tarekegn M. Prevalence and determinants of acute diarrhea

among children younger than five years old in Jabithennan District, Northwest Ethiopia, 2014. BMC Public Health 2017;17:1–8.

15 Amugsi DA, Aborigo RA, Oduro AR, et al. Socio-demographic and environmental determinants of infectious disease morbidity in children under 5 years in Ghana. Glob Health Action 2015;8:29349.

16 Kamal MM, Hasan MM, Davey R. Determinants of childhood morbidity in Bangladesh: evidence from the demographic and health survey 2011. BMJ Open 2015;5:e007538.

17 Sarker AR, Sultana M, Mahumud RA, et al. Prevalence and health care–seeking behavior for childhood diarrheal disease in Bangladesh. Glob Pediatr Heal 2016;3:2333794X16680901.

18 NIPORT and ICF. Bangladesh Demographic and Health Survey 2017-18. Dhaka, Bangladesh, and Rockville, Maryland, USA: NIPORT and ICF: 2020.

19 WHO. 2018 Global reference list of 100 core health indicators (plus health-related SDGs). World Health Organization 2018.

20 Forsberg BC, Petzold MG, Tomson G, et al. Diarrhoea case management in low-and middle-income countries: an unfinished agenda. Bull World Health Organ 2007;85:42–8.

21 Mulatya DM, Mutuku FW. Assessing Comorbidity of Diarrhea and Acute Respiratory Infections in Children Under 5 Years: Evidence From Kenya's Demographic Health Survey 2014. J Prim Care Community Health 2020;11:2150132720925190.

22 Imran MIK, Inshafi MUA, Sheikh R, et al. Risk factors for acute respiratory infection in children younger than five years in Bangladesh. Public Health 2019;173:112–9.

23 WHO. WHO child growth standards: length/height-for-age, weight-for-age, weight-for-length, weight-for-height and body mass index-for-age: methods and development. World Health Organization 2006.

24 WHO. Progress on drinking water, sanitation and hygiene: 2017 update and SDG baselines. 2017.

25 WHO. Safely managed drinking water: thematic report on drinking water 2017. 2017.

26 Rehfuess E, WHO. Fuel for life: household energy and health. World Health Organization 2006.

27 ICF. Demographic and Health Surveys Standard Recode Manual for DHS7. The Demographic and Health Surveys Program. Rockville, Maryland, U.S.A.: ICF. 2018. https://dhsprogram.com/pubs/pdf/DHSG4/Recode7_DHS_10Sep2018_DHSG4.pdf

28 Adebowale SA, Morakinyo OM, Ana GR. Housing materials as predictors of under-five mortality in Nigeria: evidence from 2013 demographic and health survey. BMC Pediatr 2017;17:1–13.

29 NIPORT M and A (Firm) & MI. Bangladesh Demographic and Health Survey, 2007. NIPORT 2009.

30 NIPORT M and A (Firm) & MII for RD. Bangladesh demographic and health survey. National Institute of Population Research and Training (NIPORT) 2011.

31 Siziya S, Muula AS, Rudatsikira E. Correlates of diarrhoea among children below the age of 5 years in Sudan. Afr Health Sci 2013;13:376–83.

32 Hasan R, Rhodes J, Thamthitiwat S, et al. Incidence and etiology of acute lower respiratory tract infections in hospitalized children younger than 5 years in rural Thailand. Pediatr Infect Dis J 2014;33:e45.

33 Vlassoff C. Gender differences in determinants and consequences of health and illness. J Health Popul Nutr 2007;25:47.

34 Murray CJL, Vos T, Lozano R, et al. Disability-adjusted life years (DALYs) for 291 diseases and injuries in 21 regions, 1990–2010: a systematic analysis for the Global Burden of Disease Study 2010. Lancet 2012;380:2197–223.

35 Walke SP, Das R, Acharya AS, et al. Incidence, pattern, and severity of acute respiratory infections among infants and toddlers of a peri-urban area of Delhi: a 12-month prospective study. Int Sch Res Not 2014;2014.

36 Tazinya AA, Halle-Ekane GE, Mbuagbaw LT, et al. Risk factors for acute respiratory infections in children under five years attending the Bamenda Regional Hospital in

Cameroon. BMC Pulm Med 2018;18:1–8.

37 Rasheda Begum M, Hasan Al Banna M, Akter S, et al. Effectiveness of WASH Education to Prevent Diarrhea among Children under five in a Community of Patuakhali, Bangladesh. doi:10.1007/s42399-020-00405-x

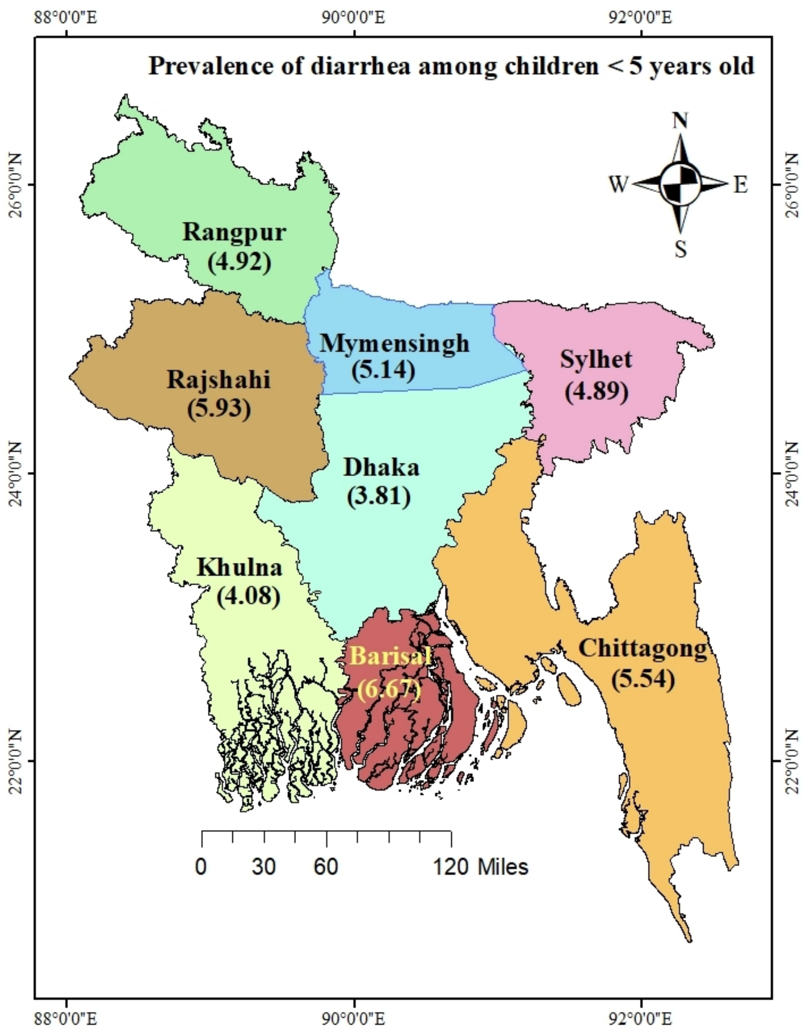

Figure 1: Division-wise distribution of prevalence (weighted) of diarrheal disease among children under five years old in Bangladeshi

215x279mm (96 x 96 DPI)

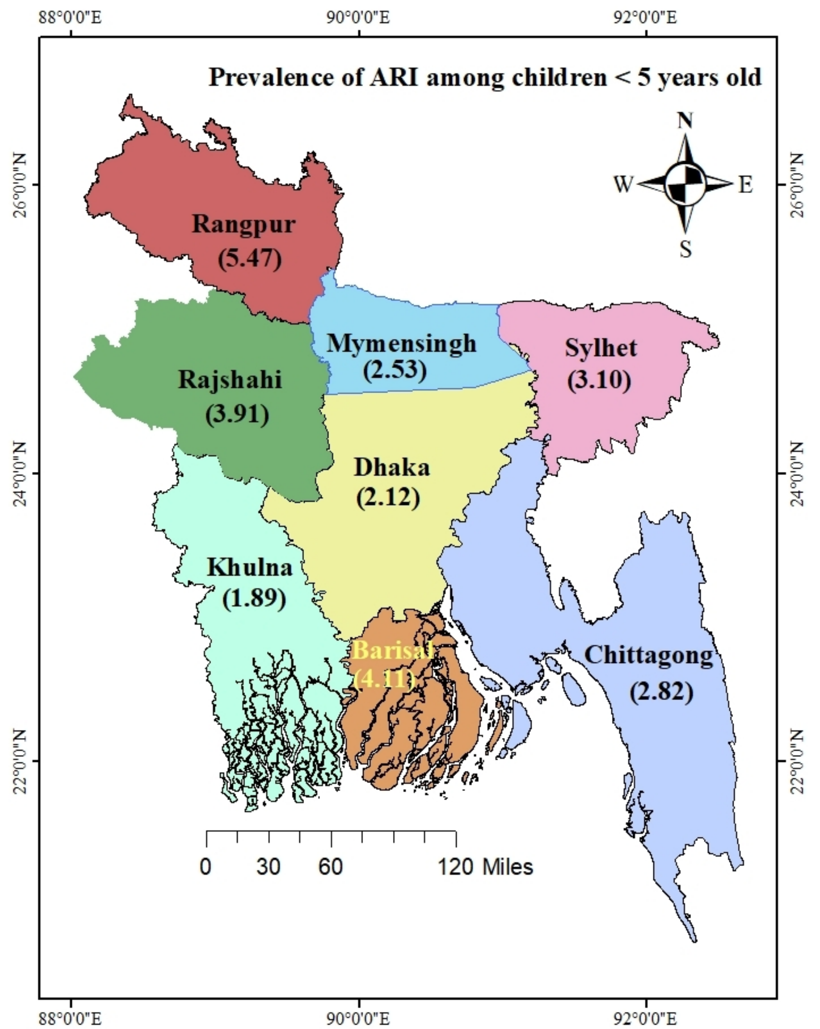

Figure 2: Division-wise distribution of prevalence (weighted) of acute respiratory infection among children under five years old in Bangladesh

215x279mm (96 x 96 DPI)

STROBE 2007 (v4) Statement—Checklist of items that should be included in reports of *cross-sectional studies*

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	Page 2
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	Page 2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	Page 3 to 4
Objectives	3	State specific objectives, including any prespecified hypotheses	Page 4
Methods			
Study design	4	Present key elements of study design early in the paper	Page 5
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	Page 5
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	Page 5
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	Page 5 to 7
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	Page 7
Bias	9	Describe any efforts to address potential sources of bias	Page 5
Study size	10	Explain how the study size was arrived at	Page 5
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	Page 5 to 7
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	Page 7
		(*b*) Describe any methods used to examine subgroups and interactions	Page 7
		(*c*) Explain how missing data were addressed	Page 5
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	Not applicable
		(*e*) Describe any sensitivity analyses	Page 7
Results			

Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	Page 8
		(b) Give reasons for non-participation at each stage	Not applicable
		(c) Consider use of a flow diagram	Not applicable
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	Page 8
		(b) Indicate number of participants with missing data for each variable of interest	Not applicable
Outcome data	15*	Report numbers of outcome events or summary measures	Not applicable
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	Page 12 to 14
		(*b*) Report category boundaries when continuous variables were categorized	Page 12 to 14
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	Not applicable
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	Not applicable
Discussion			
Key results	18	Summarise key results with reference to study objectives	Page 15
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	Page 3
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	Page 15 to 17
Generalisability	21	Discuss the generalisability (external validity) of the study results	Page 17
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	Page 18

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

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Prevalence and factors associated with childhood diarrheal disease and acute respiratory infection in Bangladesh: An analysis of a nationwide cross-sectional survey

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Word count: 4068

ABSTRACT

Objectives: This study aimed to estimate the prevalence of childhood diarrheal diseases (CDDs) and acute respiratory infections (ARIs) and also to determine the factors associated with these conditions at the population level in Bangladesh.

Setting: The study entailed an analysis of nationally representative cross-sectional secondary data from the most recent Bangladesh Demography and Health Survey (BDHS) data conducted in 2017-2018.

Participants: A total of 7,222 children < 5 years old for CDDs, and 7,215 children aged below 5 years for ARIs during the survey from mothers aged between 15 to 49 years are the participants of this study. In the bivariate and multivariable analysis, we used Pearson Chi-square test and binary logistic regression, respectively, for both outcomes.

Results: The overall prevalence of CDD and ARI among children < 5 years old were found to be 4.91% and 3.03%, respectively. Younger children were more likely to develop both CDDs and ARIs compared to their older counterparts. Children belonging to households classified as poorest and with unimproved floor materials had a higher prevalence of diarrhea than those from households identified as richest and with improved floor material, respectively. Stunted children had 40.8% higher odds of diarrhea than normal children. Being male and having mothers aged below 20 years were 48.9% and 2 times more likely to develop ARI than female counterparts and children of mothers aged 20-34 years, respectively. Children whose mothers had no formal education or had primary and secondary education had higher odds of ARI compared to children of mothers having higher education.

Conclusion: This study found that children aged below 24 months were at higher risk of having CDDs and ARIs. Thus, programs targeting these groups should be designed and emphasis should be given to those from poorest quintile to reduce CDDs and ARIs.

Keywords: Childhood diarrhea, Acute respiratory infection, Prevalence, BDHS, Bangladesh

Strengths and limitations of this study

- We used the most recent nationally representative data for this study which ensures that our findings are generalizable to children in Bangladesh.
- This study applied appropriate statistical analysis to assess the prevalence and analyze the associated factors concurrently for ARI and CDD. Therefore, this is a major contribution to ARI and CDD literature in Bangladesh.
- Nevertheless, the use of secondary data that was based on cross-sectional design limits the analysis and the causal relationship cannot be ascertained between the outcome and independent variables.
- The information was self-reported by mothers thereby putting at risk of recall bias.

INTRODUCTION

Protecting the health and wellbeing of children is a crucial component of public health and global health targets. This is exemplified in the ended Millennium Development Goals (MDGs) and the fairly new Sustainable Development Goals (SDGs), especially SDG 3.2 which seeks to reduce under-five mortality to as low as 25 per 1000 live births by 2030[1]. Nonetheless, diarrhea and acute respiratory infection (ARI) remain a major cause of morbidity and mortality among children under-five worldwide[2], with diarrheal disease constituting about 9% of under-five mortality (UNICEF, 2016). Available evidence also indicates that ARI constitutes one-fifth of all under-five mortality[3].

The severity of diarrheal disease and ARI cannot be underrated. Beyond its association with childhood mortality, both diarrheal disease and ARI among children have been linked with many child health outcomes[4,5]. In the first two years of a child where the incidence of ARI and diarrheal diseases is highest, it impedes the physical growth and development of the child, which may later translate into further adverse health events later in their adult life, that is, if the child survives[6].

Contextualizing the study, it is important to note that Bangladesh was successful in achieving the MDGs, specifically target 4 by attaining a 74% decline in under-five deaths from 1990-2015[7]. However, the country remains among the top 15 countries with a high prevalence of childhood mortality attributable to ARI and diarrheal disease[7]. Furthermore, evidence from Bangladesh shows that about 39% of all pediatric hospital admissions and, between 40-60% of total pediatric outpatient department visits were as a result of ARI[8]. This situation calls the attention of researchers to investigate ARI and diarrheal disease among children from the Bangladesh context.

Existing body of literature from Ethiopia[9], Nepal[10], and Uganda[11] have found ARI and diarrheal disease among children to be associated with household socioeconomic status. Evidence from Vietnam[12] also shows that childhood ARI and diarrheal disease were associated with rural residency. Other studies conducted elsewhere have also posited that the sex of the child and access to safe drinking water[10], sanitation[13], level of maternal education and maternal age[11], complementary feeding practices[14], breastfeeding practices[15], waste disposal[9], and household cooking fuel[16] to be significantly associated with ARI and diarrheal disease among children.

Current evidence that has used nationally representative data to investigate ARI and diarrheal disease among children in Bangladesh is sparse. To the best of our knowledge, existing current evidence has not looked at ARI and diarrheal disease concurrently. For instance, the study by Sarker et al.[17] was limited to only childhood diarrheal disease (CDD) whereas study by Sultana et al.[7] was limited to ARI. Therefore, our study is the first current evidence using nationally representative data that investigates both childhood diarrheal disease and ARI in Bangladesh. By assessing CDD and ARI concurrently, we would gain broader appreciation of childhood morbidity and mortality in Bangladesh, as well as facilitate a holistic contribution towards the attainment of SDG 3.2. Evidence shows that CDD and ARI are a major cause of morbidity and mortality among children under-five. Therefore, addressing only one aspect (say, CDD) will be like partially addressing the issue. Hence, our joint assessment of the prevalence and factors of CDD and ARI provides a holistic approach to the discourse, helping us to know the similarities in associated factors for CDD and ARI, as well as the exclusive factors for CDD and ARI. Hence, the aim of this study is to investigate the prevalence of ARI and CDD, and determine the factors associated with these two childhood morbidities in Bangladesh. Our findings are timely and relevant in preparing Bangladesh to achieve SDG 3.2, and facilitating the country's exit from the top 15 countries with a high prevalence of CDD. Knowing the prevalence of ARI and CDD will inform policy makers in their policy formulation and target setting. Moreover, identifying the factors associated with ARI and CDD is critical to developing need-based strategies to combat ARI and CDD in Bangladesh.

METHODS

Data, sampling design, and study population

In this study, the latest Bangladesh demographic and health survey (BDHS) data 2017-18 was used which is the eighth national survey conducted by the National Institute of Population Research and Training (NIPORT) of Health Education and Family Welfare Division of the Ministry of Health and Family Welfare under Training, Research and Development operational plan of 4th HPNSP (Health Population and Nutrition Sector Program)[18]. The BDHS 2017-2018 is a nationally representative cross-sectional household survey data, covering all the 8 administrative divisions of Bangladesh. Two-stage stratified sampling design was used where 675 (227 in urban areas and 448 in rural areas) enumeration areas (EAs) were selected with probability proportional to size at the first stage and then a systematic sample of 30 households was selected from each EAs which constitute a sample of approximately 20,250 households (see **Figure 1**). Detailed sampling and data collection procedures were given in the final BDHS report 2017-2018[18]. In this survey, ever-married women aged 15 to 49 years were approached for an interview in order to collect information on reproductive health, child health, and nutritional status.

Variable specification

Outcome variable

The current study focuses on two binary outcome variables: childhood diarrheal disease ("1" indicated the occurrence of diarrhea for the indicated period and "0" indicated no occurrence) and acute respiratory infection of children < 5 years old ("1" indicated the experience of ARI for the indicated period and "0" indicated no experience). A child was considered to suffer from diarrhea if the mother or primary caretaker reported that the child had diarrhea either in the last 24 hours or within the last 2 weeks. In the survey, childhood diarrheal disease was determined if the children had three or more loose or watery stools per day, in the 2 weeks preceding the survey. Similarly, symptoms of ARI of children were identified by asking their mothers if their children were ill with cough, and/or short rapid breathing, and/or difficult breathing two weeks prior to the survey[18–20]. For analysis, we combined "Yes, last two weeks" and "Yes, last 24 hours" into "Yes" for both ARI and Diarrhea.

Independent variables

Our variable selection was based on the previous studies[1,16,17,21,22] and available information in BDHS data 2017-18. The exposure (explanatory variables) of the current study consisted of administrative division (Barisal, Chittagong, Dhaka, Khulna Mymensingh, Rajshahi, Rangpur, and Sylhet), Sex of child (male, and female), current age of child (in months), mothers' age (in years), educational qualification of the parent, occupation of parent, type of place of residence, number of household members, household wealth index, household access to television and refrigerator, household floor materials, type of cooking fuel, source of drinking water, type of toilet facilities, drugs for intestinal parasites in last 6 months, birth order and nutritional status of the children (wasting, stunting, and weight for age). Nutritional status was measured by three child growth standards including stunting, wasting, and weight for age proposed by the World Health Organization (WHO). A child was said to be stunted whose height-for-age Z-score is < -2 standard deviation (-2SD) from the median. Similarly, A child was said to be wasted and underweighted whose weight for height Z- score and weight for age Z-score is < -2 standard deviation (-2SD) from the median, respectively[23]. Both mother's occupation and father's occupation was categorized as "Home maker/ No formal occupation (Not working, unemployed, student, retired)", "Poultry/Farming/Cultivator (land owner, farmer, agricultural worker, fisherman, poultry raising, cattle raising, home-based handicraft)", and "Professional" (Professional/Big business/Technical, Small business/semi-skilled & unskilled)[17].

The source of drinking water was categorized as "Improved (piped into dwelling, piped to yard/plot, public tap/standpipe, piped to neighbor, tube well or borehole, protected well, protected spring, rainwater, tanker truck, cart with small tank, bottled water)" and "Unimproved (unprotected well, unprotected spring, surface water (river/dam/lake/pond/stream/canal/irrigation channel, and other)" for the current study[1,17,24,25]. Type of toilet facilities was recategorized into "Improved (flush - to piped sewer system, flush - to septic tank, flush - to pit latrine, flush - don't know where, pit latrine - ventilated improved pit (VIP), pit latrine - with slab, composting toilet)" and "Unimproved (flush - to somewhere else, pit latrine - without slab / open pit, bucket toilet, hanging toilet/latrine, others)"[1,17,19]. Children under age of five years are the respondents of the current study whose ages were categorized into 5 categories (<12 months, 12-23 months, 24-35 months, 36-47 months, 48-59 months). Mother's age was coded as below 20 years, 20 to 34 years, and above 34 years[17]. Father's and mother's education had four categories no education, primary, secondary and higher education. Type of cooking fuel used was recategorized into “Clean fuel (electricity, liquefied petroleum gas (LPG), natural gas, and biogas)” and “Polluted fuel (coal/lignite, charcoal, wood, straw/shrub/grass, agricultural crops, and animal dung)”[26]. Birth order of the respondent was categorized as first child, second child and third and above. The household wealth index is a measure of living standard. DHS calculated household wealth index using principal component analysis (PCA) based on household’s ownership of selected assets, such as televisions and bicycles; materials used for housing construction; and types of water access and sanitation facilities which had five wealth quintiles (poorest, poorer, middle, richer, richest)[27]. Family size or number of household family members were divided into two categories (≤ five members and > five members). Floor materials were categorized into “Improved (cement, ceramic tiles, vinyl asphalt strips, parquet, polished wood)” and “Unimproved (earth, sand, dung, wood planks, palm, bamboo)”[28].

Data processing and analysis

Data management and analyses were done using SPSS version 25.0, and R version 4.0.1 for the children’s data set (KR file). Descriptive weighted prevalence was computed to show the prevalence of diarrhea and ARI among children under 5 years of age accounting the stratification and sampling weights. The weights were obtained from the women’s individual sample weight dividing by 1000000. Frequencies and category-based percentages were showed to present the descriptive characteristics of study participants. Chi-square test was performed to identify the association between considered risk factors and CDDs as well as ARIs. Binary logistic regression was carried out to assess the adjusted and crude effect of risk factors on CDDs and ARIs among children of age under five years. Both adjusted odds ratio (aOR) and unadjusted odds ratio with 95% CI were calculated in the analysis of the current study. A p-value of less than 0.05 was considered to be statistically significant.

Patient and public involvement

No patient involved

RESULTS

Background characteristics

After data cleaning, a total of 7,222 mothers having children <5 years old were included in case of diarrheal disease, and 7,215 mothers who had children <5 years were included in case of ARI in the present study. The age of the children was categorized with an 11 months interval and was almost equally distributed for the age category. More than half of the mothers were home maker who had no formal occupation. Most of the children (64.8%) in the study were from the rural area. Considering the measurement of nutritional statuses, 30.2%, 22.4%, and 8.2% of children were identified to be stunted, underweight, and wasted, respectively. Most of the households had an improved toilet facility (68.2%), and an improved source of drinking water (97.7%) (Table 1 & 2).

Table 1: Demographic characteristics and distribution of prevalence of childhood diarrheal disease (N = 7,222)

Variables	Categories	Weighted prevalence (%)	Total; n (%)	Had diarrhea Yes; n (%)	p value
Region	Barisal	6.78	732 (10.1)	50 (6.8)	0.139
	Chittagong	5.54	1147 (15.9)	64 (5.6)	
	Dhaka	3.81	1089 (15.1)	42 (3.9)	
	Khulna	4.08	758 (10.5)	32 (4.2)	
	Mymensingh	5.14	872 (12.1)	46 (5.3)	
	Rajshahi	5.93	745 (10.3)	44 (5.9)	
	Rangpur	4.92	810 (11.2)	38 (4.7)	
	Sylhet	4.89	1069 (14.8)	56 (5.2)	
Sex of child	Male	5.23	3780 (52.3)	212 (5.6)	0.065
	Female	4.56	3442 (47.7)	160 (4.6)	
Current age of child	<12 months	5.92	1453 (20.1)	95 (6.5)	**0.000**
	12-23 months	9.36	1441 (20.0)	139 (9.6)	
	24-35 months	5.39	1432 (19.8)	77 (5.4)	
	36-47 months	2.40	1375 (19.0)	36 (2.6)	
	48-59 months	1.43	1521 (21.1)	25 (1.6)	
Mothers' age in years	Below 20	6.50	806 (11.2)	53 (6.6)	**0.013**
	20-34	4.89	5776 (80.0)	299 (5.2)	
	Above 34	2.91	640 (8.9)	20 (3.1)	
Educational level of mothers	No education	6.28	548 (7.6)	31 (5.7)	0.956
	Primary	4.61	2131 (29.5)	108 (5.1)	
	Secondary	4.87	3378 (46.8)	173 (5.1)	
	Higher	4.92	1165 (16.1)	60 (5.2)	
Education level of fathers	No education	4.08	1110 (15.4)	45 (4.1)	0.244
	Primary	5.64	2575 (35.7)	146 (5.7)	
	Secondary	4.68	2255 (31.2)	116 (5.1)	
	Higher	4.53	1282 (17.8)	65 (5.1)	
Mother's occupation	Home maker/No formal occupation	5.38	3988 (55.2)	224 (5.6)	0.124
	Poultry/Farming/Cultivator	4.19	2330 (32.3)	104 (4.5)	
	Professional	4.70	904 (12.5)	44 (4.9)	
Father's occupation	Home maker/No formal occupation	1.11	60 (0.8)	1 (1.7)	0.103
	Poultry/Farming/Cultivator	4.33	1491 (20.6)	64 (4.3)	
	Professional	5.11	5671 (78.5)	307 (5.4)	
Type of place of residence	Urban	4.62	2543 (35.2)	132 (5.2)	0.910
	Rural	5.02	4679 (64.8)	240 (5.1)	

Number of household members	≤ 5 members	4.81	4108 (56.9)	210 (5.1)	0.863
	> 5 members	5.05	3114 (43.1)	162 (5.2)	
Wealth index	Poorest	6.52	1253 (17.3)	84 (6.7)	**0.022**
	Poorer	5.11	1474 (20.4)	80 (5.4)	
	Middle	5.07	1620 (22.4)	82 (5.1)	
	Richer	4.74	1428 (19.8)	70 (4.9)	
	Richest	3.24	1447 (20.0)	56 (3.9)	
Household has: television	No	4.93	3789 (52.5)	195 (5.1)	0.986
	Yes	4.89	3433 (47.5)	177 (5.2)	
Household has: refrigerator	No	4.94	5009 (69.4)	258 (5.2)	0.999
	Yes	4.85	2213 (30.6)	114 (5.2)	
Floor materials	Improved	4.04	2666 (36.9)	120 (4.5)	0.056
	Unimproved	5.40	4556 (63.1)	252 (5.5)	
Source of drinking water	Improved	4.96	7059 (97.7)	368 (5.2)	0.148#
	Unimproved	2.48	163 (2.3)	4 (2.5)	
Type of toilet facilities	Improved	4.84	4926 (68.2)	252 (5.1)	0.843
	Unimproved	5.07	2296 (31.8)	120 (5.2)	
Drugs for intestinal parasites in last 6 months	No	5.37	4219 (58.4)	241 (5.7)	**0.011**
	Yes	4.27	3003 (41.6)	131 (4.4)	
Birth order	First child	5.07	2590 (35.9)	137 (5.3)	0.429
	Second child	5.27	2359 (32.7)	129 (5.5)	
	Third and so	4.35	2273 (31.5)	106 (4.7)	
Stunting status	Normal	5.01	5044 (69.8)	269 (5.3)	0.287
	Stunted	4.66	2178 (30.2)	103 (4.7)	
Weight for age	Normal	4.77	5603 (77.6)	287 (5.1)	0.838
	Underweight	5.41	1619 (22.4)	85 (5.3)	
Wasting status	Normal	4.84	6631 (91.8)	341 (5.1)	0.914
	Wasted	5.77	591 (8.2)	31 (5.2)	
Total		4.91	7222 (100)	372 (5.2)	

The bolded p values indicate the statistical significance
 # This p value is obtained from Fisher's exact test

The results and the associated χ^2 tests shown in **Table 1** indicate that the incidence of childhood diarrheal disease in Bangladesh is significantly associated with the age of children, mothers' age, household wealth index, and drug intake for intestinal parasites. The associated χ^2 tests regarding ARI of children in Bangladesh shown in **Table 2** reveal that region, age and sex of children, mothers' age, and household having television and refrigerator were significantly associated with ARI.

Prevalence of diarrheal disease and ARI

The overall prevalence of diarrheal disease among children < 5 years old was 4.91%. The highest diarrheal prevalence was found among children from Barisal region (6.78%), followed by Rajshahi region (5.93%) **(Figure 2)**. Among the age groups, children aged between 12 to 23 months (9.36%) were most vulnerable to diarrhea, followed by <12 months old children (5.92%). Children of young mothers aged between 20 to 34 years old suffered from diarrhea more (6.50%) than those of older mothers aged above 34 years old (2.91%). Children of mothers with no formal education (6.28%) were found to be more vulnerable to diarrheal disease. Based on the five quintiles of the household wealth index, the diarrheal prevalence was higher among children from the poorest families (6.52%). A high prevalence was observed in children (5.37% vs 4.27%) who did not intake drugs for intestinal parasites in the last 6 months prior to data collection, and who were stunted (5.01% vs 4.66%). A high prevalence was observed in households that had unimproved floor materials (5.40% vs 4.04%) **(Table 1)**.

The overall prevalence of ARI among children < 5 years old was 3.03%. The highest prevalence of ARI observed in Rangpur region (5.47%), followed by Barishal (4.11%) region of Bangladesh **(Figure 3)**. Children aged between 12 to 23 months (4.10%) were found to be more vulnerable to ARI, followed by <12 months old children (4.07%). A higher prevalence of ARI was found among children of mothers aged 20 to 34 years (5.28%). ARI prevalence was higher among male (3.63%) than female children (2.36%). The prevalence of ARI is highest (3.56%) among the children whose mothers had no formal education, and a similar pattern was also observed with the educational status of fathers. Based on the socioeconomic status of the households, ARI prevalence was higher (3.98%) in the households with lower socioeconomic status **(Table 2)**.

Table 2: Demographic characteristics and distribution of prevalence of ARI (N = 7,215)

Variables	Categories	Weighted prevalence (%)	Total; n (%)	Had ARI Yes; n (%)	p value
Region	Barisal	4.11	730 (10.1)	30 (4.1)	**0.001**
	Chittagong	2.82	1145 (15.9)	31 (2.7)	
	Dhaka	2.12	1089 (15.1)	23 (2.1)	
	Khulna	1.89	758 (10.5)	15 (2.0)	
	Mymensingh	2.53	872 (12.1)	22 (2.5)	
	Rajshahi	3.91	744 (10.3)	27 (3.6)	
	Rangpur	5.47	810 (11.2)	43 (5.3)	
	Sylhet	3.10	1067 (14.8)	35 (3.3)	
Sex of child	Male	3.63	3778 (52.4)	138 (3.7)	**0.008**
	Female	2.36	3437 (47.6)	88 (2.6)	
Current age of child	<12 months	4.07	1452 (20.1)	65 (4.5)	**<0.001**
	12-23 months	4.10	1439 (19.9)	61 (4.2)	
	24-35 months	2.13	1429 (19.8)	30 (2.1)	
	36-47 months	2.81	1374 (19.0)	37 (2.7)	
	48-59 months	2.03	1521 (21.1)	33 (2.2)	
Mothers' age in years	Below 20 years	2.70	806 (11.2)	44 (5.5)	**<0.001**
	20-34 years	5.28	5769 (80.0)	163 (2.8)	
	Above 34 years	2.93	640 (8.9)	44 (5.5)	
Educational level of	No education	3.56	547 (7.6)	19 (3.5)	0.085

mothers	Primary	3.22	2130 (29.5)	70 (3.3)	
	Secondary	2.16	3374 (46.8)	88 (2.6)	
	Higher	1.40	1164 (16.1)	18 (1.6)	
Education level of fathers	No education	3.56	1110 (15.4)	40 (3.6)	0.177
	Primary	3.24	2573 (35.7)	85 (3.3)	
	Secondary	3.15	2251 (31.2)	73 (3.2)	
	Higher	1.82	1281 (17.8)	28 (2.2)	
Mother's occupation	Home maker/No formal occupation	2.53	3982 (55.2)	109 (2.7)	0.089
	Poultry/Farming/Cultivator	3.59	2329 (32.3)	82 (3.5)	
	Professional	3.74	904 (12.5)	35 (3.5)	
Father's occupation	Home maker/No formal occupation	0.0	60 (0.8)	0 (0.0)	0.190
	Poultry/Farming/Cultivator	3.63	1488 (20.6)	54 (3.6)	
	Professional	2.89	5495 (78.5)	172 (3.0)	
Type of place of residence	Urban	2.74	2541 (35.2)	77 (3.0)	0.714
	Rural	3.14	4674 (64.8)	149 (3.2)	
Number of household members	≤ 5 members	2.90	4105 (56.9)	127 (3.1)	0.829
	> 5 members	3.20	3110 (43.1)	99 (3.2)	
Wealth index	Poorest	3.98	1618 (22.4)	61 (3.8)	0.166
	Poorer	3.35	1429 (19.8)	49 (3.4)	
	Middle	2.72	1251 (17.3)	38 (3.0)	
	Richer	3.03	1444 (20.0)	45 (3.1)	
	Richest	1.90	1473 (20.4)	33 (2.2)	
Household has: television	No	3.63	3786 (52.5)	137 (3.6)	**0.013**
	Yes	2.37	3429 (47.5)	89 (2.6)	
Household has: refrigerator	No	3.38	5004 (69.4)	172 (3.4)	**0.025**
	Yes	2.22	2211 (30.6)	54 (2.4)	
Floor materials	Improved	2.49	2662 (36.9)	76 (2.9)	0.301
	Unimproved	3.33	4553 (63.1)	150 (3.3)	
Type of cooking fuel	Clean fuel	2.16	1492 (20.7)	36 (2.4)	0.073
	Polluted fuel	3.26	5723 (79.3)	190 (3.3)	
Birth order	First child	2.89	2588 (35.9)	73 (2.8)	0.460
	Second child	2.65	2358 (32.7)	81 (3.4)	
	Third and so	3.40	2269 (31.4)	72 (3.2)	
Stunting status	Normal	3.06	5039 (69.8)	153 (3.0)	0.476
	Stunted	2.90	2176 (30.2)	73 (3.4)	
Weight for age	Normal	3.32	5597 (77.6)	176 (3.1)	0.912
	Underweight	3.03	1618 (22.4)	50 (3.1)	
Wasting status	Normal	3.03	6624 (91.8)	204 (3.1)	0.390
	Wasted	2.99	591 (8.2)	22 (3.7)	
Total		3.03	7215 (100)	226 (3.1)	

The bolded p values indicate the statistical significance

Factors associated with childhood diarrheal disease

Table 3 shows the factors influencing the diarrheal prevalence of children under five years old in Bangladesh. Both unadjusted and adjusted (multivariable) logistic regression analyses were done, where adjusted regression model was employed to control for possible confounding effects. The adjusted model shows that male children were 11.5% more likely to experience diarrhea, compared to female children (adjusted Odd Ratio [aOR] = 1.115, 95% Confidence Interval [CI] = 1.010, 1.347). The diarrheal disease was significantly associated with the age of the children: below 12 to 23 months old children (aOR = 4.193, 95% CI = 2.916, 6.029) were at the highest risk to develop diarrhea, followed by those below 12 months old (aOR = 2.477, 95% CI = 1.666, 3.682), compared to the children aged 58 to 59 months. Children aged 24 to 35 months old showed 2.241 times higher odds of experiencing diarrheal disease compared to their older counterparts (aOR = 2.241, 95% CI = 1.523, 3.297). We also found a statistically significant association between childhood diarrheal disease and household wealth index. Children belonging to the poorest household wealth index category were 2.21 times more likely to develop diarrhea, compared to the children from the richest households (aOR = 2.210, 95% CI = 1.102, 4.432). Children from households with unimproved floor materials were 2.168 times more likely to have diarrhea than those from households with improved floor materials (aOR = 2.168, 95% CI = 1.369, 3.435). It was also found that stunted children were 71.8% more prone to have diarrhea than those who were normal (aOR = 1.718, 95% CI = 1.153, 1.955). It was also found that children from Barisal region (aOR = 1.762, 95% CI = 1.157, 2.198) were most diarrhea prone than those in Dhaka region **(Table 3)**.

Table 3: Binary logistic regression analysis of factors associated with childhood diarrhea

Variables	Categories	Unadjusted		Adjusted	
		OR	95% CI	OR	95% CI
Region (Ref: Dhaka)	Chittagong	1.473	(0.989, 2.194)	1.089	(0.747, 1.589)
	Barisal	**1.828****	(1.199, 2.785)	**1.762****	(1.157, 2.198)
	Khulna	1.099	(0.687, 1.757)	0.901	(0.569, 1.425)
	Mymensingh	1.388	(0.905, 2.130)	1.156	(0.756, 1.768)
	Rajshahi	**1.565***	(1.014, 2.414)	1.270	(0.830, 1.944)
	Rangpur	1.227	(0.784, 1.922)	1.028	(0.656, 1.611)
	Sylhet	1.378	(0.915, 2.075)	1.015	(0.685, 1.505)
Sex of child (ref: female)	Male	1.219	(0.987, 1.505)	**1.115***	(1.010, 1.374)
Current age of child (Ref: 48-59 months)	<12 months	**4.186*****	(2.678, 6.543)	**2.477*****	(1.666, 3.682)
	12-23 months	**6.388*****	(4.147, 9.843)	**4.193*****	(2.916, 6.029)
	24-35 months	**3.401*****	(2.153, 5.371)	**2.241*****	(1.523, 3.297)
	36-47 months	1.609	(0.961, 2.694)	1.009	(0.644, 1.581)
Mothers' age in years (Ref: 20-34)	Below 20	1.289	(0.953, 1.744)	0.920	(0.646, 1.311)
	Above 34	0.591	(0.373, 0.936)	0.600	(0.366, 1.130)
Educational level of mothers (Ref: Higher)	No education	1.104	(0.707, 1.725)	0.897	(0.530, 1.517)
	Primary	0.983	(0.711, 1.359)	**0.708***	(0.477, 0.989)
	Secondary	0.994	(0.735, 1.344)	0.714	(0.511, 0.998)
Education level of fathers (Ref: No education)	Primary	**1.423***	(1.011, 2.002)	0.918	(0.668, 1.262)
	Secondary	1.283	(0.903, 1.825)	0.727	(0.510, 1.035)
	Higher	1.264	(0.857, 1.865)	1.058	(0.727, 1.479)
Mother's occupation (ref: Home maker/No formal occupation)	Poultry/Farming/ Cultivator	**0.785***	(0.619, 0.996)	0.850	(0.650, 1.110)
	Professional	0.860	(0.617, 1.198)	0.880	(0.625, 1.239)

Father's occupation (ref: Home maker/No formal occupation)	Poultry/Farming/ Cultivator	2.646	(0.36, 19.402)	1.105	(0.360, 17.182)
	Professional	3.377	(0.466, 24.45)	1.120	(0.474, 20.117)
Type of place of residence (ref: Urban)	Rural	0.988	(0.794, 1.228)	0.871	(0.677, 1.122)
Number of household members (ref: ≤ 5 members)	> 5 members	1.019	(0.825, 1.257)	0.907	(0.726, 1.131)
Wealth index (ref: Richest)	Poorest	1.076	(0.784, 1.477)	**2.210***	(1.102, 4.432)
	Poorer	1.348	(0.985, 1.844)	1.214	(0.907, 2.426)
	Middle	0.967	(0.697, 1.341)	0.963	(0.204, 1.669)
	Richer	0.755	(0.533, 1.069)	1.157	(0.534, 2.385)
Household has: television (ref: No)	Yes	1.002	(0.813, 1.235)	0.771	(0.588, 1.010)
Household has: refrigerator (ref: No)	Yes	1.000	(0.798, 1.254)	0.662	(0.480, 1.131)
Floor materials (ref: Improved)	Unimproved	1.242	(0.994, 1.552)	**2.168****	(1.369, 3.435)
Source of drinking water (ref: Improved)	Unimproved	0.457	(0.169, 1.241)	0.496	(0.180, 1.367)
Type of toilet facilities (ref: Improved)	Unimproved	1.023	(0.818, 1.279)	0.980	(0.745, 1.288)
Drugs for intestinal parasites in last 6 months (ref: No)	Yes	**0.753***	(0.605, 0.936)	0.935	(0.731, 1.196)
Birth order (ref: First child)	Second child	1.036	(0.809, 1.136)	0.922	(0.703, 1.211)
	Third and so	0.876	(0.675, 1.136)	0.832	(0.606, 1.141)
Stunting status (ref: Normal)	Stunted	0.881	(0.698, 1.112)	**1.718***	(1.153, 1.955)
Weight for age (ref: Normal)	Underweight	1.026	(0.800, 1.316)	1.234	(0.893, 1.705)
Wasting status (ref: Normal)	Wasted	1.021	(0.700, 1.490)	0.904	(0.594, 1.375)

The bolded values (ORs) indicate the statistical significance.
*p < 0.05; **p < 0.01; ***p < 0.001; OR = Odds Ratio; CI = Confidence Interval.

Factors associated with ARI of children

Our multivariate regression analysis on ARI revealed that children aged <12 months (aOR = 1.883, 95% CI = 1.206, 2.939) and 12 – 23 months (aOR = 1.780, 95% CI = 1.141, 2.776) had 88.3% and 78%, respectively, higher prevalence of ARI compared to children aged 48 – 59 months old. In the present study, male children were 48.9% more likely to have ARI than female children (aOR = 1.489, 95% CI = 1.132, 1.960). Children of mothers aged < 20 years had two times higher odds of having ARI compared to those of mothers aged between 20 – 34 years (aOR = 2.166, 95% CI = 1.403, 3.344). we also found that the educational qualification of mothers had a great influence on ARI of children. Children of mothers having no formal education (aOR = 2.331, 95% CI = 1.139, 4.771), primary education (aOR = 2.488, 95% CI = 1.190, 5.202), and secondary education (aOR = 2.654, 95% CI = 1.102, 6.392) had higher prevalence of ARI compared to those whose mothers had above secondary or higher education. Children of professional mothers were 68.4% more likely to have ARI compared to those of mothers who were home maker or had no formal occupation (aOR = 1.684, 95% CI = 1.121, 2.53). Similar to the diarrheal prevalence, geographical location was one of the emergent influential factors for ARI of children. From the distribution of

ARI cases, it was found that children who lived in Rangpur region (aOR = 2.710, 95% CI = 1.474, 4.982) were most diarrhea prone, followed by Barisal region (aOR = 2.143, 95% CI = 1.127,4.077). In addition, children from Sylhet region were 93.2% more likely to develop ARI, compared to those from Khulna region (aOR = 1.932, 95% CI = 1.021, 3.653) **(Table 4).**

Table 4: Binary logistic regression analysis of factors associated with ARI of children

Variables	Categories	Unadjusted		Adjusted	
		OR	95% CI	OR	95% CI
Region (ref: Khulna)	Barisal	**2.123***	(1.133, 3.979)	**2.143***	(1.127,4.077)
	Chittagong	1.378	(0.739, 2.571)	1.454	(0.767, 2.754)
	Dhaka	1.069	(0.554, 2.062)	1.163	(0.584, 2.318)
	Sylhet	1.680	(0.911, 3.098)	**1.932***	(1.021, 3.653)
	Mymensingh	1.282	(0.660, 2.489)	1.322	(0.673, 2.596)
	Rajshahi	1.865	(0.984, 3.536)	1.851	(0.971, 3.528)
	Rangpur	**2.777****	(1.530, 5.041)	**2.710****	(1.474, 4.982)
Sex of child (ref: female)	Male	**1.443****	(1.100, 1.893)	**1.489****	(1.132, 1.960)
Current age of child (ref: 48-59 months)	<12 months	**2.113****	(1.381, 3.233)	**1.883****	(1.206, 2.939)
	12-23 months	**1.996****	(1.299, 3.068)	**1.780***	(1.141, 2.776)
	24-35 months	0.967	(0.587, 1.594)	0.900	(0.542, 1.496)
	36-47 months	1.248	(0.776, 2.007)	1.226	(0.759, 1.979)
Mothers' age in years (ref: 20-34 years)	Below 20 years	**1.986*****	(1.411, 2.794)	**2.166*****	(1.403, 3.344)
	Above 34 years	1.052	(0.650, 1.704)	1.095	(0.649, 1.847)
Educational level of mothers (ref: Higher)	No education	**2.182***	(1.086, 4.384)	**2.331***	(1.139, 4.771)
	Primary	**2.052***	(1.034, 4.072)	**2.488***	(1.190, 5.202)
	Secondary	1.581	(0.746, 3.354)	**2.654***	(1.102, 6.392)
Education level of fathers (ref: Higher)	No education	**1.673***	(1.025, 2.730)	1.816	(0.961, 3.433)
	Primary	1.529	(0.992, 2.356)	1.471	(0.840, 2.578)
	Secondary	1.500	(0.965, 2.332)	1.495	(0.888, 2.518)
Mother's occupation (ref: Home maker/No formal occupation)	Poultry/Farming/ Cultivator	1.297	(0.969, 1.735)	1.184	(0.852, 1.643)
	Professional	1.431	(0.971, 2.109)	**1.684***	(1.121, 2.53)
Father's occupation (ref: Professional)	No formal occupation	0.0	(0.0, 0.0)	0.0	(0.0, 0.0)
	Poultry/Farming/ Cultivator	1.203	(0.881, 1.642)	1.094	(0.777, 1.540)
Type of place of residence (ref: Urban)	Rural	1.054	(0.797, 1.393)	0.866	(0.620, 1.210)
Number of household members (ref: ≤ 5 members)	> 5 members	1.030	(0.789, 1.435)	1.021	(0.768, 1.358)
Wealth index (ref: Richest)	Poorest	**1.710***	(1.113, 2.627)	1.439	(0.524, 3.951)
	Poorer	1.549	(0.990, 2.424)	1.459	(0.548, 3.886)
	Middle	1.367	(0.852, 2.193)	1.384	(0.593, 3.229)
	Richer	1.404	(0.890, 2.213)	1.186	(0.664, 2.119)
Household has: television (ref: No)	Yes	0.710	(0.541, 0.931)	0.803	(0.561, 1.150)
Household has: refrigerator (ref: No)	Yes	**0.703***	(0.516, 0.959)	1.039	(0.659, 1.639)
Floor materials (ref: Improved)	Unimproved	1.159	(0.876, 1.534)	0.653	(0.366, 1.164)

Type of cooking fuel (ref: Clean fuel)	Polluted fuel	1.389	(0.968-1.992)	1.098	(0.661, 1.823)
Birth order (ref: Third and so)	First child	0.886	(0.636, 1.233)	0.705	(0.457, 1.088)
	Second child	1.085	(0.786, 1.499)	1.076	(0.754, 1.535)
Stunting status (ref: Stunted)	Normal	0.902	(0.679, 1.198)	0.896	(0.637, 1.260)
Weight for age (ref: Underweight)	Normal	1.018	(0.740, 1.401)	1.119	(0.746, 1.679)
Wasting status (ref: Wasted)	Normal	0.822	(0.525, 1.286)	0.797	(0.486, 1.306)

The bolded values (ORs) indicate the statistical significance.
*p < 0.05; **p < 0.01; ***p < 0.001; OR = Odds Ratio; CI = Confidence Interval.

DISCUSSION

Although Bangladesh met the MDG targets, it still remains among the top 15 countries with high cases of CDD and ARI[7]. Therefore, to ensure that there is a greater understanding of the situation of ARI and CDD in Bangladesh, as well as facilitate its potential to achieve SDG 3.2, we investigated the prevalence of ARI and CDD, and determined the factors that are associated with these two childhood health events. Our study indicates that the prevalence of CDD and ARI was 4.91% and 3.03% respectively, with the prevalence for both outcomes being highest for children born to younger mothers (20-34 years), mothers with no formal education, those in lower socioeconomic status. The ARI prevalence observed reflects a trend of decline in the prevalence of ARI from previous rounds of the BDHS survey reports[7,29,30].

Concerning the factors associated with ARI and CDD, the results of our study show that it was significantly associated with the sex of the child, with male children being at higher risk of ARI or CDD. This finding is in line with earlier studies from Bangladesh[7], Ethiopia[14], Nepal[10], Sudan[31], and Thailand[32] that have reported higher risk of ARI and CDD among male children. This could probably be due to differences in genetics that places males at higher risk of diseases and other health events compared to women[7]. Another plausible explanation could be due to higher reporting for male children, which is reinforced by mothers' preference for the male child[33]. As such, they are able to notice changes in the health status of the male child early and report to the hospital accordingly.

There is a myriad of evidence suggesting that ARI and CDD are most prevalent in the first two years of a child's life, thus, making children <12 months and those between 12-23 months being at higher risk of ARI or CDD[13,17,34]. Our finding provides confirmation of this association. Moreover, the finding from this study indicates that although the prevalence of ARI and CDD is higher within the first two years of a child's life, the risk of developing ARI or CDD is highest in children between 12-23 months, which supports Sarker et al.[17] findings that the prevalence of CDD is highest for children aged 1 to 2 years compared to those less than a year old. However, our findings that younger child age is associated with higher prevalence and risk of ARI and CDD could be explained from the point that, the immune system of the child is delicate at that early age, thereby putting them at increased risk of infections[35]. Furthermore, children which such early years tend to be heavily dependent on their mothers and therefore, require appropriate feeding that is proportional to their age[17]. Hence, when mothers slack in their responsibilities to provide safe and appropriate feeding to the children at that age, then their risk of ARI and CDD increases.

We found a significant association between household wealth status and risk of CDD, with children belonging to the poorest household having greater likelihood of developing the diarrheal disease. This corroborates previous related studies from Bangladesh[16,17] and Nepal[10] that also reported higher risk of CDD among children belonging to poor households. This could be justified from the perspective that poorer households have difficulty in meeting their nutritional needs and adopting appropriate feeding practices which may exacerbate their risk of diarrheal infection[10]. This is further iterated in our finding that stunted children had a higher risk of CDD.

Congruent to existing literature[3,11], our study indicates that there is significant association between formal education and ARI, with lower odds of ARI being reported among children whose mothers had formal education compared to those whose mothers had no formal education. A plausible justification for this finding could be that children spend more time with their mothers; therefore, the mother's educational attainment will reflect in the quality of care that they will provide to their child, which may either increase the risk or protection against ARI[36]. Hence, emphasizing the need to promote formal education among women.

Beyond these individual and household factors, we found statistically significant association between geographical region and the risks of ARI and CDD. It was found that children who lived in Rangpur region and Barisal region were at higher risk of developing ARI or CDD. This is consistent with previous studies from Bangladesh[17] that also found similar findings in relation to the regional differences in the prevalence of ARI and CDD. Begum and her colleagues also reported a higher diarrheal prevalence among children < 5 years old in the similar setting and found that water, sanitation and hygiene (WASH) education to the mothers was effective to reduce the burden of diarrhea [37]. According to Sarker et al[17], regions like Barisal are densely populated and is also characterized by the existence of more rivers and water reservoirs that create an enabling environment for diarrheal disease to spread among the population. Perhaps, this could be the reason for the high prevalence of ARI and CDD within the Barisal region.

STRENGTHS AND LIMITATIONS

The strength of this study lies in the use of the most recent nationally representative data for this study which ensures that our findings are generalizable to children in Bangladesh. Also, the study applied appropriate statistical analysis to assess the prevalence and analyze the associated factors concurrently for ARI and CDD. Hence, our findings are valid and reliable. Nevertheless, there were some limitations to our study which noteworthy. First, the use of secondary data that was based on cross-sectional design limits the analysis. As such, causal relationship cannot be ascertained between the outcome and independent variables. The information was self-reported by mothers thereby putting at risk of recall bias. Perhaps, a longitudinal study that seeks to assess the factors that influence CDD and ARI could establish some sort of causality. Notwithstanding, these limitations do not override the validity and reliability of our findings.

CONCLUSION

We also conclude that there are individual, household and geographic factors that exacerbate the risk of ARI and CDD (children born to mothers of younger age, mothers with no formal education, belonging to lower socioeconomic households, being a male child, being stunted, and residing in Barisal and Rangpur regions). Therefore, we recommend that the government of Bangladesh commit resources, policies and interventions geared towards ARI and CDD reduction to the identified at-risk groups. Also, there is the need to augment formal education for women in Bangladesh to accelerate the realization of SDG 3.2, and complete eradication of ARI and CDD related child mortality in the country. Further studies can be conducted to explore how culture also permeates the dynamics of ARI and CDD in Bangladesh, in order to ensure that interventions and policies developed are culturally sensitive to facilitate acceptance and adherence.

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Author contributions

Satyajit Kundu: Conceptualization, methodology, data curation, formal analysis, writing - original draft, final approval; **Subarna Kundu:** Conceptualization, methodology, data curation, formal analysis, writing - original draft, final approval; **Md. Hasan Al Banna**: Writing - original draft; **Bright Opoku Ahinkorah**: Writing - original draft, review and editing, final approval; **Abdul-Aziz Seidu**: Writing - original draft, review and editing; **Joshua Okyere**: Writing - original draft, review and editing.

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Patient consent for publication

Not required.

Ethics approval

The current study used publicly available secondary data provided by Bangladesh demographic and health survey (BDHS) which is collected by following standardized data collection procedures[38]. Procedures and questionnaires for standard DHS surveys have been ethically reviewed and approved by ICF Institutional Review Board (IRB), Maryland, USA. The data is downloaded from the demographic and health survey website for research purposes. Written informed consent from the respondents enrolled in the survey and other ethical review documents are available at: https://dhsprogram.com/methodology/Protecting-the-Privacy-of-DHS-Survey-Respondents.cfm._The data set is available online publicly for all researchers, hence there is no need to approve[38].

Data sharing statement

The study used data from the 2017-2018 Bangladesh Demographic and Health Survey. The data set is available at: https://dhsprogram.com/data/available-datasets.cfm[38].

REFERENCES

1 Apanga PA, Kumbeni MT. Factors associated with diarrhoea and acute respiratory infection

in children under-5 years old in Ghana: an analysis of a national cross-sectional survey. BMC Pediatr 2021;21:1–8.

2 WHO. WHO Global Health Observatory (GHO) data. Causes of child mortality 2015. 2015.

3 Pinzón-Rondón ÁM, Aguilera-Otalvaro P, Zárate-Ardila C, et al. Acute respiratory infection in children from developing nations: a multi-level study. Paediatr Int Child Health 2016;:1–7.

4 Nasanen-Gilmore SPK, Saha S, Rasul I, et al. Household environment and behavioral determinants of respiratory tract infection in infants and young children in northern Bangladesh. Am J Hum Biol 2015;27:851–8.

5 WHO. Ending preventable child deaths from pneumonia and diarrhoea by 2025: the integrated Global Action Plan for Pneumonia and Diarrhoea (GAPPD). 2013.

6 Dewey KG, Mayers DR. Early child growth: how do nutrition and infection interact? Matern Child Nutr 2011;7:129–42.

7 Sultana M, Sarker AR, Sheikh N, et al. Prevalence, determinants and health care-seeking behavior of childhood acute respiratory tract infections in Bangladesh. PLoS One 2019;14:e0210433.

8 Kabir AL, Amin MR, Mollah MAH, et al. Respiratory disorders in under-five children attending different hospitals of Bangladesh: A cross sectional survey. J Respir Med Res Treat 2016;11:2016–183615.

9 Gebru T, Taha M, Kassahun W. Risk factors of diarrhoeal disease in under-five children among health extension model and non-model families in Sheko district rural community, Southwest Ethiopia: comparative cross-sectional study. BMC Public Health 2014;14:1–6.

10 Budhathoki SS, Bhattachan M, Yadav AK, et al. Eco-social and behavioural determinants of diarrhoea in under-five children of Nepal: a framework analysis of the existing literature. Trop Med Health 2016;44:1–7.

11 Bbaale E. Determinants of diarrhoea and acute respiratory infection among under-fives in Uganda. Australas Med J 2011;4:400.

12 Lee H-Y, Huy N Van, Choi S. Determinants of early childhood morbidity and proper treatment responses in Vietnam: results from the Multiple Indicator Cluster Surveys, 2000–2011. Glob Health Action 2016;9:29304.

13 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 J Prev Med 2013;3:446.

14 Anteneh ZA, Andargie K, Tarekegn M. Prevalence and determinants of acute diarrhea among children younger than five years old in Jabithennan District, Northwest Ethiopia, 2014. BMC Public Health 2017;17:1–8.

15 Amugsi DA, Aborigo RA, Oduro AR, et al. Socio-demographic and environmental determinants of infectious disease morbidity in children under 5 years in Ghana. Glob Health Action 2015;8:29349.

16 Kamal MM, Hasan MM, Davey R. Determinants of childhood morbidity in Bangladesh: evidence from the demographic and health survey 2011. BMJ Open 2015;5:e007538.

17 Sarker AR, Sultana M, Mahumud RA, et al. Prevalence and health care–seeking behavior for childhood diarrheal disease in Bangladesh. Glob Pediatr Heal 2016;3:2333794X16680901.

18 NIPORT and ICF. Mitra and associates. Dhaka, Bangladesh: ICF International. Bangladesh Demographic and Health Survey 2017-18. Dhaka, Bangladesh, and Rockville, Maryland, USA: NIPORT and ICF: 2020. https://dhsprogram.com/pubs/pdf/fr265/fr265.pdf

19 WHO. 2018 Global reference list of 100 core health indicators (plus health-related SDGs). World Health Organization 2018.

20 Forsberg BC, Petzold MG, Tomson G, et al. Diarrhoea case management in low-and middle-income countries: an unfinished agenda. Bull World Health Organ 2007;85:42–8.

21 Mulatya DM, Mutuku FW. Assessing Comorbidity of Diarrhea and Acute Respiratory Infections in Children Under 5 Years: Evidence From Kenya's Demographic Health Survey 2014. J Prim Care Community Health 2020;11:2150132720925190.

22 Imran MIK, Inshafi MUA, Sheikh R, et al. Risk factors for acute respiratory infection in children younger than five years in Bangladesh. Public Health 2019;173:112–9.

23 WHO. WHO child growth standards: length/height-for-age, weight-for-age, weight-for-length, weight-for-height and body mass index-for-age: methods and development. World Health Organization 2006.

24 WHO. Progress on drinking water, sanitation and hygiene: 2017 update and SDG baselines. 2017.

25 WHO. Safely managed drinking water: thematic report on drinking water 2017. 2017.

26 Rehfuess E, WHO. Fuel for life: household energy and health. World Health Organization 2006.

27 ICF. Demographic and Health Surveys Standard Recode Manual for DHS7. The Demographic and Health Surveys Program. Rockville, Maryland, U.S.A.: ICF. 2018. https://dhsprogram.com/pubs/pdf/DHSG4/Recode7_DHS_10Sep2018_DHSG4.pdf

28 Adebowale SA, Morakinyo OM, Ana GR. Housing materials as predictors of under-five mortality in Nigeria: evidence from 2013 demographic and health survey. BMC Pediatr 2017;17:1–13.

29 NIPORT M and A (Firm) & MI. Bangladesh Demographic and Health Survey, 2007. NIPORT 2009.

30 NIPORT M and A (Firm) & MII for RD. Bangladesh demographic and health survey. National Institute of Population Research and Training (NIPORT) 2011.

31 Siziya S, Muula AS, Rudatsikira E. Correlates of diarrhoea among children below the age of 5 years in Sudan. Afr Health Sci 2013;13:376–83.

32 Hasan R, Rhodes J, Thamthitiwat S, et al. Incidence and etiology of acute lower respiratory tract infections in hospitalized children younger than 5 years in rural Thailand. Pediatr Infect Dis J 2014;33:e45.

33 Vlassoff C. Gender differences in determinants and consequences of health and illness. J Health Popul Nutr 2007;25:47.

34 Murray CJL, Vos T, Lozano R, et al. Disability-adjusted life years (DALYs) for 291 diseases and injuries in 21 regions, 1990–2010: a systematic analysis for the Global Burden of Disease Study 2010. Lancet 2012;380:2197–223.

35 Walke SP, Das R, Acharya AS, et al. Incidence, pattern, and severity of acute respiratory infections among infants and toddlers of a peri-urban area of Delhi: a 12-month prospective study. Int Sch Res Not 2014;2014.

36 Tazinya AA, Halle-Ekane GE, Mbuagbaw LT, et al. Risk factors for acute respiratory infections in children under five years attending the Bamenda Regional Hospital in Cameroon. BMC Pulm Med 2018;18:1–8.

37 Rasheda Begum M, Hasan Al Banna M, Akter S, et al. Effectiveness of WASH Education to Prevent Diarrhea among Children under five in a Community of Patuakhali, Bangladesh. doi:10.1007/s42399-020-00405-x

[dataset] 38 National Institute of Population Research and Training (NIPORT), Mitra and Associates and II. Bangladesh Demographic and Health Survey 2014. Data Extract from BDKR7RFL.SAV. Bangladesh Demographic and Health Surveys (BDHS), Version 7, BDHS and ICF [Distributors]. 2020. https://dhsprogram.com/data/available-datasets.cfm (accessed 4 Oct 2021).

Figure captions:

Figure 1. Flow chart for the participants selection

Figure 2. Division-wise distribution of prevalence (weighted) of diarrheal disease among children under five years old in Bangladeshi

Figure 3. Division-wise distribution of prevalence (weighted) of acute respiratory infection among children under five years old in Bangladesh

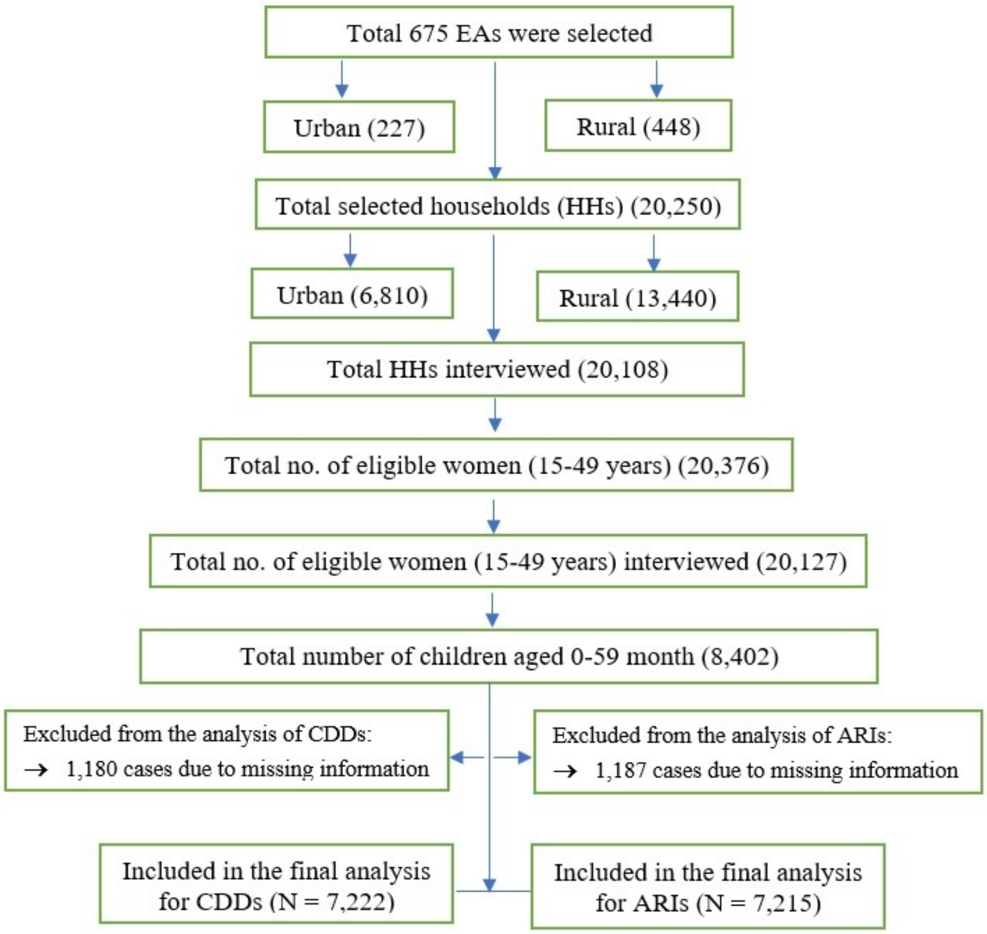

Figure 1. Flow chart for the participant selection

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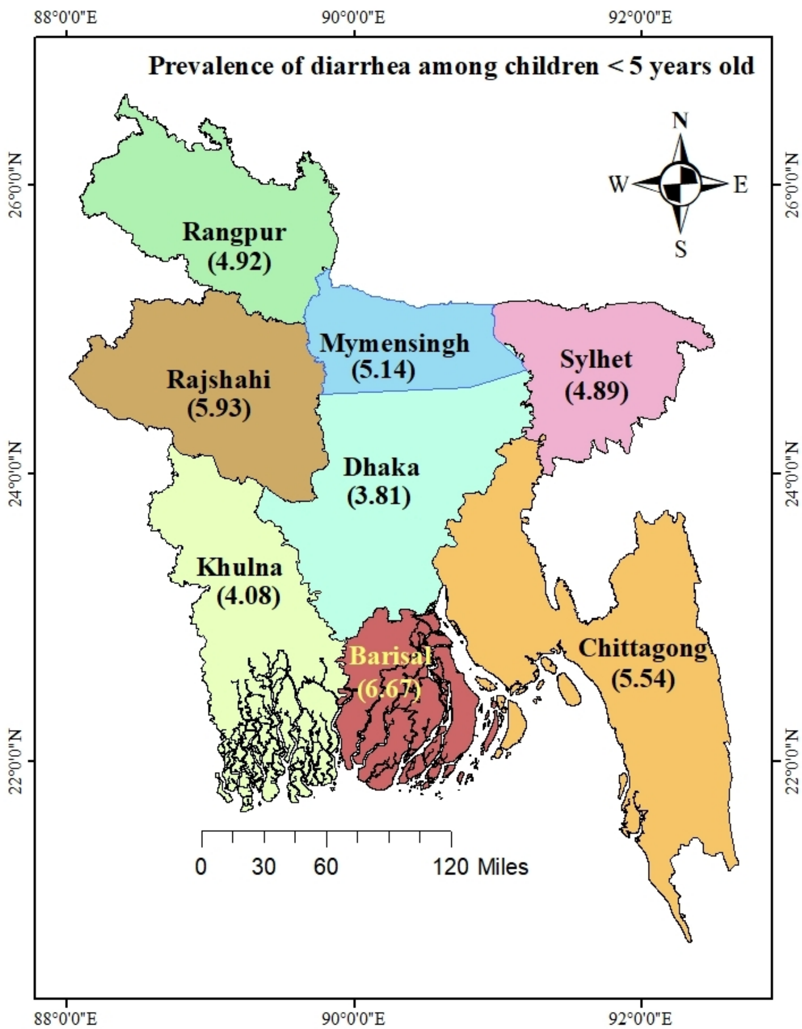

Figure 2. Division-wise distribution of prevalence (weighted) of diarrheal disease among children under five years old in Bangladeshi

215x279mm (96 x 96 DPI)

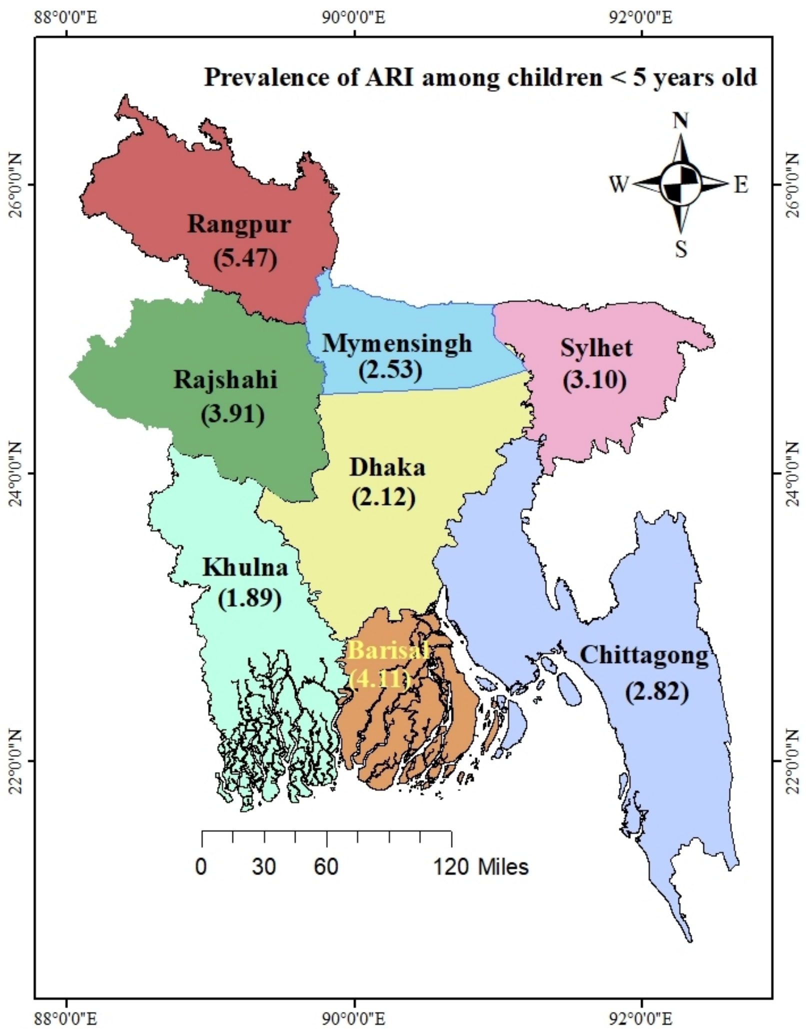

Figure 3. Division-wise distribution of prevalence (weighted) of acute respiratory infection among children under five years old in Bangladesh

215x279mm (96 x 96 DPI)

STROBE 2007 (v4) Statement—Checklist of items that should be included in reports of *cross-sectional studies*

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	Page 2
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	Page 2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	Page 3 to 4
Objectives	3	State specific objectives, including any prespecified hypotheses	Page 4
Methods			
Study design	4	Present key elements of study design early in the paper	Page 5
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	Page 5
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	Page 5
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	Page 5 to 7
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	Page 7
Bias	9	Describe any efforts to address potential sources of bias	Page 5
Study size	10	Explain how the study size was arrived at	Page 5
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	Page 5 to 7
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	Page 7
		(*b*) Describe any methods used to examine subgroups and interactions	Page 7
		(*c*) Explain how missing data were addressed	Page 5
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	Not applicable
		(*e*) Describe any sensitivity analyses	Page 7
Results			

Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	Page 8
		(b) Give reasons for non-participation at each stage	Not applicable
		(c) Consider use of a flow diagram	Not applicable
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	Page 8
		(b) Indicate number of participants with missing data for each variable of interest	Not applicable
Outcome data	15*	Report numbers of outcome events or summary measures	Not applicable
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	Page 12 to 14
		(*b*) Report category boundaries when continuous variables were categorized	Page 12 to 14
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	Not applicable
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	Not applicable
Discussion			
Key results	18	Summarise key results with reference to study objectives	Page 15
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	Page 3
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	Page 15 to 17
Generalisability	21	Discuss the generalisability (external validity) of the study results	Page 17
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	Page 18

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

Prevalence of and factors associated with childhood diarrheal disease and acute respiratory infection in Bangladesh: An analysis of a nationwide cross-sectional survey

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Prevalence of and factors associated with childhood diarrheal disease and acute respiratory infection in Bangladesh: An analysis of a nationwide cross-sectional survey

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ABSTRACT

Objectives: This study aimed to estimate the prevalence of childhood diarrheal diseases (CDDs) and acute respiratory infections (ARIs) and also to determine the factors associated with these conditions at the population level in Bangladesh.

Setting: The study entailed an analysis of nationally representative cross-sectional secondary data from the most recent Bangladesh Demography and Health Survey (BDHS) data conducted in 2017-2018.

Participants: A total of 7,222 children < 5 years old for CDDs, and 7,215 children aged below 5 years for ARIs during the survey from mothers aged between 15 to 49 years are the participants of this study. In the bivariate and multivariable analysis, we used Pearson Chi-square test and binary logistic regression, respectively, for both outcomes.

Results: The overall prevalence of CDD and ARI among children < 5 years old were found to be 4.91% and 3.03%, respectively. Younger children were more likely to develop both CDDs and ARIs compared to their older counterparts. Children belonging to households classified as poorest and with unimproved floor materials had a higher prevalence of diarrhea than those from households identified as richest and with improved floor material, respectively. Stunted children had 40.8% higher odds of diarrhea than normal children. Being male and having mothers aged below 20 years were 48.9% and 2 times more likely to develop ARI than female counterparts and children of mothers aged 20-34 years, respectively. Children whose mothers had no formal education or had primary and secondary education had higher odds of ARI compared to children of mothers having higher education.

Conclusion: This study found that children aged below 24 months were at higher risk of having CDDs and ARIs. Thus, programs targeting these groups should be designed and emphasis should be given to those from poorest quintile to reduce CDDs and ARIs.

Keywords: Childhood diarrhea, Acute respiratory infection, Prevalence, BDHS, Bangladesh

Strengths and limitations of this study

- We used the most recent nationally representative data for this study which ensures that our findings are generalizable to children in Bangladesh.
- This study applied appropriate statistical analysis to assess the prevalence and analyze the associated factors concurrently for ARI and CDD. Therefore, this is a major contribution to ARI and CDD literature in Bangladesh.
- Nevertheless, the use of secondary data that was based on cross-sectional design limits the analysis and the causal relationship cannot be ascertained between the outcome and independent variables.
- The information was self-reported by mothers thereby putting at risk of recall bias.

INTRODUCTION

Protecting the health and wellbeing of children is a crucial component of public health and global health targets. This is exemplified in the ended Millennium Development Goals (MDGs) and the fairly new Sustainable Development Goals (SDGs), especially SDG 3.2 which seeks to reduce under-five mortality to as low as 25 per 1000 live births by 2030[1]. Nonetheless, diarrhea and acute respiratory infection (ARI) remain a major cause of morbidity and mortality among children under-five worldwide[2], with diarrheal disease constituting about 9% of under-five mortality (UNICEF, 2016). Available evidence also indicates that ARI constitutes one-fifth of all under-five mortality[3].

The severity of diarrheal disease and ARI cannot be underrated. Beyond its association with childhood mortality, both diarrheal disease and ARI among children have been linked with many child health outcomes[4,5]. In the first two years of a child where the incidence of ARI and diarrheal diseases is highest, it impedes the physical growth and development of the child, which may later translate into further adverse health events later in their adult life, that is, if the child survives[6].

Contextualizing the study, it is important to note that Bangladesh was successful in achieving the MDGs, specifically target 4 by attaining a 74% decline in under-five deaths from 1990-2015[7]. However, the country remains among the top 15 countries with a high prevalence of childhood mortality attributable to ARI and diarrheal disease[7]. Furthermore, evidence from Bangladesh shows that about 39% of all pediatric hospital admissions and, between 40-60% of total pediatric outpatient department visits were as a result of ARI[8]. This situation calls the attention of researchers to investigate ARI and diarrheal disease among children from the Bangladesh context.

Existing body of literature from Ethiopia[9], Nepal[10], and Uganda[11] have found ARI and diarrheal disease among children to be associated with household socioeconomic status. Evidence from Vietnam[12] also shows that childhood ARI and diarrheal disease were associated with rural residency. Other studies conducted elsewhere have also posited that the sex of the child and access to safe drinking water[10], sanitation[13], level of maternal education and maternal age[11], complementary feeding practices[14], breastfeeding practices[15], waste disposal[9], and household cooking fuel[16] to be significantly associated with ARI and diarrheal disease among children.

Current evidence that has used nationally representative data to investigate ARI and diarrheal disease among children in Bangladesh is sparse. To the best of our knowledge, existing current evidence has not looked at ARI and diarrheal disease concurrently. For instance, the study by Sarker et al.[17] was limited to only childhood diarrheal disease (CDD) whereas study by Sultana et al.[7] was limited to ARI. Therefore, our study is the first current evidence using nationally representative data that investigates both childhood diarrheal disease and ARI in Bangladesh. By assessing CDD and ARI concurrently, we would gain broader appreciation of childhood morbidity and mortality in Bangladesh, as well as facilitate a holistic contribution towards the attainment of SDG 3.2. Evidence shows that CDD and ARI are a major cause of morbidity and mortality among children under-five. Therefore, addressing only one aspect (say, CDD) will be like partially addressing the issue. Hence, our joint assessment of the prevalence and factors of CDD and ARI provides a holistic approach to the discourse, helping us to know the similarities in associated factors for CDD and ARI, as well as the exclusive factors for CDD and ARI. Hence, the aim of this study is to investigate the prevalence of ARI and CDD, and determine the factors associated with these two childhood morbidities in Bangladesh. Our findings are timely and relevant in preparing Bangladesh to achieve SDG 3.2, and facilitating the country's exit from the top 15 countries with a high prevalence of CDD. Knowing the prevalence of ARI and CDD will inform policy makers in their policy formulation and target setting. Moreover, identifying the factors associated with ARI and CDD is critical to developing need-based strategies to combat ARI and CDD in Bangladesh.

METHODS

Data, sampling design, and study population

In this study, the latest Bangladesh demographic and health survey (BDHS) data 2017-18 was used which is the eighth national survey conducted by the National Institute of Population Research and Training (NIPORT) of Health Education and Family Welfare Division of the Ministry of Health and Family Welfare under Training, Research and Development operational plan of 4th HPNSP (Health Population and Nutrition Sector Program)[18]. The BDHS 2017-2018 is a nationally representative cross-sectional household survey data, covering all the 8 administrative divisions of Bangladesh. Two-stage stratified sampling design was used where 675 (227 in urban areas and 448 in rural areas) enumeration areas (EAs) were selected with probability proportional to size at the first stage and then a systematic sample of 30 households was selected from each EAs which constitute a sample of approximately 20,250 households (see **Figure 1**). Detailed sampling and data collection procedures were given in the final BDHS report 2017-2018[18]. In this survey, ever-married women aged 15 to 49 years were approached for an interview in order to collect information on reproductive health, child health, and nutritional status.

Variable specification

Outcome variable

The current study focuses on two binary outcome variables: childhood diarrheal disease ("1" indicated the occurrence of diarrhea for the indicated period and "0" indicated no occurrence) and acute respiratory infection of children < 5 years old ("1" indicated the experience of ARI for the indicated period and "0" indicated no experience). A child was considered to suffer from diarrhea if the mother or primary caretaker reported that the child had diarrhea either in the last 24 hours or within the last 2 weeks. In the survey, childhood diarrheal disease was determined if the children had three or more loose or watery stools per day, in the 2 weeks preceding the survey. Similarly, symptoms of ARI of children were identified by asking their mothers if their children were ill with cough, and/or short rapid breathing, and/or difficult breathing two weeks prior to the survey[18–20]. For analysis, we combined "Yes, last two weeks" and "Yes, last 24 hours" into "Yes" for both ARI and Diarrhea.

Independent variables

Our variable selection was based on the previous studies[1,16,17,21,22] and available information in BDHS data 2017-18. The exposure (explanatory variables) of the current study consisted of administrative division (Barisal, Chittagong, Dhaka, Khulna Mymensingh, Rajshahi, Rangpur, and Sylhet), Sex of child (male, and female), current age of child (in months), mothers' age (in years), educational qualification of the parent, occupation of parent, type of place of residence, number of household members, household wealth index, household access to television and refrigerator, household floor materials, type of cooking fuel, source of drinking water, type of toilet facilities, drugs for intestinal parasites in last 6 months, birth order and nutritional status of the children (wasting, stunting, and weight for age). Nutritional status was measured by three child growth standards including stunting, wasting, and weight for age proposed by the World Health Organization (WHO). A child was said to be stunted whose height-for-age Z-score is < -2 standard deviation (-2SD) from the median. Similarly, A child was said to be wasted and underweighted whose weight for height Z- score and weight for age Z-score is < -2 standard deviation (-2SD) from the median, respectively[23]. Both mother's occupation and father's occupation were categorized as "Home maker/ No formal occupation (Not working, unemployed, student, retired)", "Poultry/Farming/Cultivator (land owner, farmer, agricultural worker, fisherman, poultry raising, cattle raising, home-based handicraft)", and "Professional" (Professional/Big business/Technical, Small business/semi-skilled & unskilled)[17].

The source of drinking water was categorized as "Improved (piped into dwelling, piped to yard/plot, public tap/standpipe, piped to neighbor, tube well or borehole, protected well, protected spring, rainwater, tanker truck, cart with small tank, bottled water)" and "Unimproved (unprotected well, unprotected spring, surface water (river/dam/lake/pond/stream/canal/irrigation channel, and other)" for the current study[1,17,24,25]. Type of toilet facilities was recategorized into "Improved (flush - to piped sewer system, flush - to septic tank, flush - to pit latrine, flush - don't know where, pit latrine - ventilated improved pit (VIP), pit latrine - with slab, composting toilet)" and "Unimproved (flush - to somewhere else, pit latrine - without slab / open pit, bucket toilet, hanging toilet/latrine, others)"[1,17,19]. Children under age of five years are the respondents of the current study whose ages were categorized into 5 categories (<12 months, 12-23 months, 24-35 months, 36-47 months, 48-59 months). Mother's age was coded as below 20 years, 20 to 34 years, and above 34 years[17]. Father's and mother's education had four categories: no education, primary, secondary and higher education. Type of cooking fuel used was recategorized into "Clean fuel (electricity, liquefied petroleum gas (LPG), natural gas, and biogas)" and "Polluted fuel (coal/lignite, charcoal, wood, straw/shrub/grass, agricultural crops, and animal dung)"[26]. Birth order of the respondent was categorized as first child, second child and third and above. The household wealth index is a measure of living standard. DHS calculated household wealth index using principal component analysis (PCA) based on household's ownership of selected assets, such as televisions and bicycles; materials used for housing construction; and types of water access and sanitation facilities which had five wealth quintiles (poorest, poorer, middle, richer, richest)[27]. Family size or number of household family members were divided into two categories (≤ five members and > five members). Floor materials were categorized into "Improved (cement, ceramic tiles, vinyl asphalt strips, parquet, polished wood)" and "Unimproved (earth, sand, dung, wood planks, palm, bamboo)"[28].

Data processing and analysis

Data management and analyses were done using SPSS version 25.0, and R version 4.0.1 for the children's data set (KR file). Descriptive weighted prevalence was computed to show the prevalence of diarrhea and ARI among children under 5 years of age accounting the stratification and sampling weights. The weights were obtained from the women's individual sample weight dividing by 1000000. Frequencies and category-based percentages were showed to present the descriptive characteristics of study participants. Chi-square test was performed to identify the association between considered risk factors and CDDs as well as ARIs. Binary logistic regression was carried out to assess the adjusted and crude effect of risk factors on CDDs and ARIs among children of age under five years. Both adjusted odds ratio (aOR) and unadjusted odds ratio with 95% CI were calculated in the analysis of the current study. A p-value of less than 0.05 was considered to be statistically significant.

Patient and public involvement

No patient involved

RESULTS

Background characteristics

After data cleaning, a total of 7,222 mothers having children <5 years old were included in case of diarrheal disease, and 7,215 mothers who had children <5 years were included in case of ARI in the present study. The age of the children was categorized with an 11 months interval and was almost equally distributed for the age category. More than half of the mothers were home maker who had no formal occupation. Most of the children (64.8%) in the study were from the rural area. Considering the measurement of nutritional statuses, 30.2%, 22.4%, and 8.2% of children were identified to be stunted, underweight, and wasted, respectively. Most of the households had an improved toilet facility (68.2%), and an improved source of drinking water (97.7%) (Table 1 & 2).

Table 1: Demographic characteristics and distribution of prevalence of childhood diarrheal disease (N = 7,222)

Variables	Categories	Weighted prevalence (%)	Total; n (%)	Had diarrhea Yes; n (%)	p value
Region	Barisal	6.78	732 (10.1)	50 (6.8)	0.139
	Chittagong	5.54	1147 (15.9)	64 (5.6)	
	Dhaka	3.81	1089 (15.1)	42 (3.9)	
	Khulna	4.08	758 (10.5)	32 (4.2)	
	Mymensingh	5.14	872 (12.1)	46 (5.3)	
	Rajshahi	5.93	745 (10.3)	44 (5.9)	
	Rangpur	4.92	810 (11.2)	38 (4.7)	
	Sylhet	4.89	1069 (14.8)	56 (5.2)	
Sex of child	Male	5.23	3780 (52.3)	212 (5.6)	0.065
	Female	4.56	3442 (47.7)	160 (4.6)	
Current age of child	<12 months	5.92	1453 (20.1)	95 (6.5)	**0.000**
	12-23 months	9.36	1441 (20.0)	139 (9.6)	
	24-35 months	5.39	1432 (19.8)	77 (5.4)	
	36-47 months	2.40	1375 (19.0)	36 (2.6)	
	48-59 months	1.43	1521 (21.1)	25 (1.6)	
Mothers' age in years	Below 20	6.50	806 (11.2)	53 (6.6)	**0.013**
	20-34	4.89	5776 (80.0)	299 (5.2)	
	Above 34	2.91	640 (8.9)	20 (3.1)	
Educational level of mothers	No education	6.28	548 (7.6)	31 (5.7)	0.956
	Primary	4.61	2131 (29.5)	108 (5.1)	
	Secondary	4.87	3378 (46.8)	173 (5.1)	
	Higher	4.92	1165 (16.1)	60 (5.2)	
Education level of fathers	No education	4.08	1110 (15.4)	45 (4.1)	0.244
	Primary	5.64	2575 (35.7)	146 (5.7)	
	Secondary	4.68	2255 (31.2)	116 (5.1)	
	Higher	4.53	1282 (17.8)	65 (5.1)	
Mother's occupation	Home maker/No formal occupation	5.38	3988 (55.2)	224 (5.6)	0.124
	Poultry/Farming/Cultivator	4.19	2330 (32.3)	104 (4.5)	
	Professional	4.70	904 (12.5)	44 (4.9)	
Father's occupation	Home maker/No formal occupation	1.11	60 (0.8)	1 (1.7)	0.103
	Poultry/Farming/Cultivator	4.33	1491 (20.6)	64 (4.3)	
	Professional	5.11	5671 (78.5)	307 (5.4)	
Type of place of residence	Urban	4.62	2543 (35.2)	132 (5.2)	0.910
	Rural	5.02	4679 (64.8)	240 (5.1)	

Number of household members	≤ 5 members	4.81	4108 (56.9)	210 (5.1)	0.863
	> 5 members	5.05	3114 (43.1)	162 (5.2)	
Wealth index	Poorest	6.52	1253 (17.3)	84 (6.7)	**0.022**
	Poorer	5.11	1474 (20.4)	80 (5.4)	
	Middle	5.07	1620 (22.4)	82 (5.1)	
	Richer	4.74	1428 (19.8)	70 (4.9)	
	Richest	3.24	1447 (20.0)	56 (3.9)	
Household has: television	No	4.93	3789 (52.5)	195 (5.1)	0.986
	Yes	4.89	3433 (47.5)	177 (5.2)	
Household has: refrigerator	No	4.94	5009 (69.4)	258 (5.2)	0.999
	Yes	4.85	2213 (30.6)	114 (5.2)	
Floor materials	Improved	4.04	2666 (36.9)	120 (4.5)	0.056
	Unimproved	5.40	4556 (63.1)	252 (5.5)	
Source of drinking water	Improved	4.96	7059 (97.7)	368 (5.2)	0.148[#]
	Unimproved	2.48	163 (2.3)	4 (2.5)	
Type of toilet facilities	Improved	4.84	4926 (68.2)	252 (5.1)	0.843
	Unimproved	5.07	2296 (31.8)	120 (5.2)	
Drugs for intestinal parasites in last 6 months	No	5.37	4219 (58.4)	241 (5.7)	**0.011**
	Yes	4.27	3003 (41.6)	131 (4.4)	
Birth order	First child	5.07	2590 (35.9)	137 (5.3)	0.429
	Second child	5.27	2359 (32.7)	129 (5.5)	
	Third and so	4.35	2273 (31.5)	106 (4.7)	
Stunting status	Normal	5.01	5044 (69.8)	269 (5.3)	0.287
	Stunted	4.66	2178 (30.2)	103 (4.7)	
Weight for age	Normal	4.77	5603 (77.6)	287 (5.1)	0.838
	Underweight	5.41	1619 (22.4)	85 (5.3)	
Wasting status	Normal	4.84	6631 (91.8)	341 (5.1)	0.914
	Wasted	5.77	591 (8.2)	31 (5.2)	
Total		4.91	7222 (100)	372 (5.2)	

The bolded p values indicate the statistical significance
[#] This p value is obtained from Fisher's exact test

The results and the associated χ^2 tests shown in **Table 1** indicate that the incidence of childhood diarrheal disease in Bangladesh is significantly associated with the age of children, mothers' age, household wealth index, and drug intake for intestinal parasites. The associated χ^2 tests regarding ARI of children in Bangladesh shown in **Table 2** reveal that region, age and sex of children, mothers' age, and household having television and refrigerator were significantly associated with ARI.

Prevalence of diarrheal disease and ARI

The overall prevalence of diarrheal disease among children < 5 years old was 4.91%. The highest diarrheal prevalence was found among children from Barisal region (6.78%), followed by Rajshahi region (5.93%) **(Figure 2)**. Among the age groups, children aged between 12 to 23 months (9.36%) were most vulnerable to diarrhea, followed by <12 months old children (5.92%). Children of young mothers aged between 20 to 34 years old suffered from diarrhea more (6.50%) than those of older mothers aged above 34 years old (2.91%). Children of mothers with no formal education (6.28%) were found to be more vulnerable to diarrheal disease. Based on the five quintiles of the household wealth index, the diarrheal prevalence was higher among children from the poorest families (6.52%). A high prevalence was observed in children (5.37% vs 4.27%) who did not intake drugs for intestinal parasites in the last 6 months prior to data collection, and who were stunted (5.01% vs 4.66%). A high prevalence was observed in households that had unimproved floor materials (5.40% vs 4.04%) **(Table 1)**.

The overall prevalence of ARI among children < 5 years old was 3.03%. The highest prevalence of ARI observed in Rangpur region (5.47%), followed by Barishal (4.11%) region of Bangladesh **(Figure 3)**. Children aged between 12 to 23 months (4.10%) were found to be more vulnerable to ARI, followed by <12 months old children (4.07%). A higher prevalence of ARI was found among children of mothers aged 20 to 34 years (5.28%). ARI prevalence was higher among male (3.63%) than female children (2.36%). The prevalence of ARI is highest (3.56%) among the children whose mothers had no formal education, and a similar pattern was also observed with the educational status of fathers. Based on the socioeconomic status of the households, ARI prevalence was higher (3.98%) in the households with lower socioeconomic status **(Table 2)**.

Table 2: Demographic characteristics and distribution of prevalence of ARI (N = 7,215)

Variables	Categories	Weighted prevalence (%)	Total; n (%)	Had ARI Yes; n (%)	p value
Region	Barisal	4.11	730 (10.1)	30 (4.1)	**0.001**
	Chittagong	2.82	1145 (15.9)	31 (2.7)	
	Dhaka	2.12	1089 (15.1)	23 (2.1)	
	Khulna	1.89	758 (10.5)	15 (2.0)	
	Mymensingh	2.53	872 (12.1)	22 (2.5)	
	Rajshahi	3.91	744 (10.3)	27 (3.6)	
	Rangpur	5.47	810 (11.2)	43 (5.3)	
	Sylhet	3.10	1067 (14.8)	35 (3.3)	
Sex of child	Male	3.63	3778 (52.4)	138 (3.7)	**0.008**
	Female	2.36	3437 (47.6)	88 (2.6)	
Current age of child	<12 months	4.07	1452 (20.1)	65 (4.5)	**<0.001**
	12-23 months	4.10	1439 (19.9)	61 (4.2)	
	24-35 months	2.13	1429 (19.8)	30 (2.1)	
	36-47 months	2.81	1374 (19.0)	37 (2.7)	
	48-59 months	2.03	1521 (21.1)	33 (2.2)	
Mothers' age in years	Below 20 years	2.70	806 (11.2)	44 (5.5)	**<0.001**
	20-34 years	5.28	5769 (80.0)	163 (2.8)	
	Above 34 years	2.93	640 (8.9)	44 (5.5)	
Educational level of	No education	3.56	547 (7.6)	19 (3.5)	0.085

mothers	Primary	3.22	2130 (29.5)	70 (3.3)	
	Secondary	2.16	3374 (46.8)	88 (2.6)	
	Higher	1.40	1164 (16.1)	18 (1.6)	
Education level of fathers	No education	3.56	1110 (15.4)	40 (3.6)	0.177
	Primary	3.24	2573 (35.7)	85 (3.3)	
	Secondary	3.15	2251 (31.2)	73 (3.2)	
	Higher	1.82	1281 (17.8)	28 (2.2)	
Mother's occupation	Home maker/No formal occupation	2.53	3982 (55.2)	109 (2.7)	0.089
	Poultry/Farming/Cultivator	3.59	2329 (32.3)	82 (3.5)	
	Professional	3.74	904 (12.5)	35 (3.5)	
Father's occupation	Home maker/No formal occupation	0.0	60 (0.8)	0 (0.0)	0.190
	Poultry/Farming/Cultivator	3.63	1488 (20.6)	54 (3.6)	
	Professional	2.89	5495 (78.5)	172 (3.0)	
Type of place of residence	Urban	2.74	2541 (35.2)	77 (3.0)	0.714
	Rural	3.14	4674 (64.8)	149 (3.2)	
Number of household members	≤ 5 members	2.90	4105 (56.9)	127 (3.1)	0.829
	> 5 members	3.20	3110 (43.1)	99 (3.2)	
Wealth index	Poorest	3.98	1618 (22.4)	61 (3.8)	0.166
	Poorer	3.35	1429 (19.8)	49 (3.4)	
	Middle	2.72	1251 (17.3)	38 (3.0)	
	Richer	3.03	1444 (20.0)	45 (3.1)	
	Richest	1.90	1473 (20.4)	33 (2.2)	
Household has: television	No	3.63	3786 (52.5)	137 (3.6)	**0.013**
	Yes	2.37	3429 (47.5)	89 (2.6)	
Household has: refrigerator	No	3.38	5004 (69.4)	172 (3.4)	**0.025**
	Yes	2.22	2211 (30.6)	54 (2.4)	
Floor materials	Improved	2.49	2662 (36.9)	76 (2.9)	0.301
	Unimproved	3.33	4553 (63.1)	150 (3.3)	
Type of cooking fuel	Clean fuel	2.16	1492 (20.7)	36 (2.4)	0.073
	Polluted fuel	3.26	5723 (79.3)	190 (3.3)	
Birth order	First child	2.89	2588 (35.9)	73 (2.8)	0.460
	Second child	2.65	2358 (32.7)	81 (3.4)	
	Third and so	3.40	2269 (31.4)	72 (3.2)	
Stunting status	Normal	3.06	5039 (69.8)	153 (3.0)	0.476
	Stunted	2.90	2176 (30.2)	73 (3.4)	
Weight for age	Normal	3.32	5597 (77.6)	176 (3.1)	0.912
	Underweight	3.03	1618 (22.4)	50 (3.1)	
Wasting status	Normal	3.03	6624 (91.8)	204 (3.1)	0.390
	Wasted	2.99	591 (8.2)	22 (3.7)	
Total		3.03	7215 (100)	226 (3.1)	

The bolded p values indicate the statistical significance

Factors associated with childhood diarrheal disease

Table 3 shows the factors influencing the diarrheal prevalence of children under five years old in Bangladesh. Both unadjusted and adjusted (multivariable) logistic regression analyses were done, where adjusted regression model was employed to control for possible confounding effects. The adjusted model shows that male children were 11.5% more likely to experience diarrhea, compared to female children (adjusted Odd Ratio [aOR] = 1.115, 95% Confidence Interval [CI] = 1.010, 1.347). The diarrheal disease was significantly associated with the age of the children: below 12 to 23 months old children (aOR = 4.193, 95% CI = 2.916, 6.029) were at the highest risk to develop diarrhea, followed by those below 12 months old (aOR = 2.477, 95% CI = 1.666, 3.682), compared to the children aged 58 to 59 months. Children aged 24 to 35 months old showed 2.241 times higher odds of experiencing diarrheal disease compared to their older counterparts (aOR = 2.241, 95% CI = 1.523, 3.297). We also found a statistically significant association between childhood diarrheal disease and household wealth index. Children belonging to the poorest household wealth index category were 2.21 times more likely to develop diarrhea, compared to the children from the richest households (aOR = 2.210, 95% CI = 1.102, 4.432). Children from households with unimproved floor materials were 2.168 times more likely to have diarrhea than those from households with improved floor materials (aOR = 2.168, 95% CI = 1.369, 3.435). It was also found that stunted children were 71.8% more prone to have diarrhea than those who were normal (aOR = 1.718, 95% CI = 1.153, 1.955). It was also found that children from Barisal region (aOR = 1.762, 95% CI = 1.157, 2.198) were most diarrhea prone than those in Dhaka region **(Table 3)**.

Table 3: Binary logistic regression analysis of factors associated with childhood diarrhea

Variables	Categories	Unadjusted		Adjusted	
		OR	95% CI	OR	95% CI
Region (Ref: Dhaka)	Chittagong	1.473	(0.989, 2.194)	1.089	(0.747, 1.589)
	Barisal	**1.828****	(1.199, 2.785)	**1.762****	(1.157, 2.198)
	Khulna	1.099	(0.687, 1.757)	0.901	(0.569, 1.425)
	Mymensingh	1.388	(0.905, 2.130)	1.156	(0.756, 1.768)
	Rajshahi	**1.565***	(1.014, 2.414)	1.270	(0.830, 1.944)
	Rangpur	1.227	(0.784, 1.922)	1.028	(0.656, 1.611)
	Sylhet	1.378	(0.915, 2.075)	1.015	(0.685, 1.505)
Sex of child (ref: female)	Male	1.219	(0.987, 1.505)	**1.115***	(1.010, 1.374)
Current age of child (Ref: 48-59 months)	<12 months	**4.186*****	(2.678, 6.543)	**2.477*****	(1.666, 3.682)
	12-23 months	**6.388*****	(4.147, 9.843)	**4.193*****	(2.916, 6.029)
	24-35 months	**3.401*****	(2.153, 5.371)	**2.241*****	(1.523, 3.297)
	36-47 months	1.609	(0.961, 2.694)	1.009	(0.644, 1.581)
Mothers' age in years (Ref: 20-34)	Below 20	1.289	(0.953, 1.744)	0.920	(0.646, 1.311)
	Above 34	0.591	(0.373, 0.936)	0.600	(0.366, 1.130)
Educational level of mothers (Ref: Higher)	No education	1.104	(0.707, 1.725)	0.897	(0.530, 1.517)
	Primary	0.983	(0.711, 1.359)	**0.708***	(0.477, 0.989)
	Secondary	0.994	(0.735, 1.344)	0.714	(0.511, 0.998)
Education level of fathers (Ref: No education)	Primary	**1.423***	(1.011, 2.002)	0.918	(0.668, 1.262)
	Secondary	1.283	(0.903, 1.825)	0.727	(0.510, 1.035)
	Higher	1.264	(0.857, 1.865)	1.058	(0.727, 1.479)
Mother's occupation (ref: Home maker/No formal occupation)	Poultry/Farming/ Cultivator	**0.785***	(0.619, 0.996)	0.850	(0.650, 1.110)
	Professional	0.860	(0.617, 1.198)	0.880	(0.625, 1.239)

Father's occupation (ref: Home maker/No formal occupation)	Poultry/Farming/ Cultivator	2.646	(0.36, 19.402)	1.105	(0.360, 17.182)
	Professional	3.377	(0.466, 24.45)	1.120	(0.474, 20.117)
Type of place of residence (ref: Urban)	Rural	0.988	(0.794, 1.228)	0.871	(0.677, 1.122)
Number of household members (ref: ≤ 5 members)	> 5 members	1.019	(0.825, 1.257)	0.907	(0.726, 1.131)
Wealth index (ref: Richest)	Poorest	1.076	(0.784, 1.477)	**2.210***	(1.102, 4.432)
	Poorer	1.348	(0.985, 1.844)	1.214	(0.907, 2.426)
	Middle	0.967	(0.697, 1.341)	0.963	(0.204, 1.669)
	Richer	0.755	(0.533, 1.069)	1.157	(0.534, 2.385)
Household has: television (ref: No)	Yes	1.002	(0.813, 1.235)	0.771	(0.588, 1.010)
Household has: refrigerator (ref: No)	Yes	1.000	(0.798, 1.254)	0.662	(0.480, 1.131)
Floor materials (ref: Improved)	Unimproved	1.242	(0.994, 1.552)	**2.168****	(1.369, 3.435)
Source of drinking water (ref: Improved)	Unimproved	0.457	(0.169, 1.241)	0.496	(0.180, 1.367)
Type of toilet facilities (ref: Improved)	Unimproved	1.023	(0.818, 1.279)	0.980	(0.745, 1.288)
Drugs for intestinal parasites in last 6 months (ref: No)	Yes	**0.753***	(0.605, 0.936)	0.935	(0.731, 1.196)
Birth order (ref: First child)	Second child	1.036	(0.809, 1.136)	0.922	(0.703, 1.211)
	Third and so	0.876	(0.675, 1.136)	0.832	(0.606, 1.141)
Stunting status (ref: Normal)	Stunted	0.881	(0.698, 1.112)	**1.718***	(1.153, 1.955)
Weight for age (ref: Normal)	Underweight	1.026	(0.800, 1.316)	1.234	(0.893, 1.705)
Wasting status (ref: Normal)	Wasted	1.021	(0.700, 1.490)	0.904	(0.594, 1.375)

The bolded values (ORs) indicate the statistical significance.
*p < 0.05; **p < 0.01; ***p < 0.001; OR = Odds Ratio; CI = Confidence Interval.

Factors associated with ARI of children

Our multivariate regression analysis on ARI revealed that children aged <12 months (aOR = 1.883, 95% CI = 1.206, 2.939) and 12 – 23 months (aOR = 1.780, 95% CI = 1.141, 2.776) had 88.3% and 78%, respectively, higher prevalence of ARI compared to children aged 48 – 59 months old. In the present study, male children were 48.9% more likely to have ARI than female children (aOR = 1.489, 95% CI = 1.132, 1.960). Children of mothers aged < 20 years had two times higher odds of having ARI compared to those of mothers aged between 20 – 34 years (aOR = 2.166, 95% CI = 1.403, 3.344). we also found that the educational qualification of mothers had a great influence on ARI of children. Children of mothers having no formal education (aOR = 2.331, 95% CI = 1.139, 4.771), primary education (aOR = 2.488, 95% CI = 1.190, 5.202), and secondary education (aOR = 2.654, 95% CI = 1.102, 6.392) had higher prevalence of ARI compared to those whose mothers had above secondary or higher education. Children of professional mothers were 68.4% more likely to have ARI compared to those of mothers who were home maker or had no formal occupation (aOR = 1.684, 95% CI = 1.121, 2.53). Similar to the diarrheal prevalence, geographical location was one of the emergent influential factors for ARI of children. From the distribution of

ARI cases, it was found that children who lived in Rangpur region (aOR = 2.710, 95% CI = 1.474, 4.982) were most diarrhea prone, followed by Barisal region (aOR = 2.143, 95% CI = 1.127,4.077). In addition, children from Sylhet region were 93.2% more likely to develop ARI, compared to those from Khulna region (aOR = 1.932, 95% CI = 1.021, 3.653) **(Table 4).**

Table 4: Binary logistic regression analysis of factors associated with ARI of children

Variables	Categories	Unadjusted		Adjusted	
		OR	95% CI	OR	95% CI
Region (ref: Khulna)	Barisal	**2.123***	(1.133, 3.979)	**2.143***	(1.127,4.077)
	Chittagong	1.378	(0.739, 2.571)	1.454	(0.767, 2.754)
	Dhaka	1.069	(0.554, 2.062)	1.163	(0.584, 2.318)
	Sylhet	1.680	(0.911, 3.098)	**1.932***	(1.021, 3.653)
	Mymensingh	1.282	(0.660, 2.489)	1.322	(0.673, 2.596)
	Rajshahi	1.865	(0.984, 3.536)	1.851	(0.971, 3.528)
	Rangpur	**2.777****	(1.530, 5.041)	**2.710****	(1.474, 4.982)
Sex of child (ref: female)	Male	**1.443****	(1.100, 1.893)	**1.489****	(1.132, 1.960)
Current age of child (ref: 48-59 months)	<12 months	**2.113****	(1.381, 3.233)	**1.883****	(1.206, 2.939)
	12-23 months	**1.996****	(1.299, 3.068)	**1.780***	(1.141, 2.776)
	24-35 months	0.967	(0.587, 1.594)	0.900	(0.542, 1.496)
	36-47 months	1.248	(0.776, 2.007)	1.226	(0.759, 1.979)
Mothers' age in years (ref: 20-34 years)	Below 20 years	**1.986*****	(1.411, 2.794)	**2.166*****	(1.403, 3.344)
	Above 34 years	1.052	(0.650, 1.704)	1.095	(0.649, 1.847)
Educational level of mothers (ref: Higher)	No education	**2.182***	(1.086, 4.384)	**2.331***	(1.139, 4.771)
	Primary	**2.052***	(1.034, 4.072)	**2.488***	(1.190, 5.202)
	Secondary	1.581	(0.746, 3.354)	**2.654***	(1.102, 6.392)
Education level of fathers (ref: Higher)	No education	**1.673***	(1.025, 2.730)	1.816	(0.961, 3.433)
	Primary	1.529	(0.992, 2.356)	1.471	(0.840, 2.578)
	Secondary	1.500	(0.965, 2.332)	1.495	(0.888, 2.518)
Mother's occupation (ref: Home maker/No formal occupation)	Poultry/Farming/ Cultivator	1.297	(0.969, 1.735)	1.184	(0.852, 1.643)
	Professional	1.431	(0.971, 2.109)	**1.684***	(1.121, 2.53)
Father's occupation (ref: Professional)	No formal occupation	0.0	(0.0, 0.0)	0.0	(0.0, 0.0)
	Poultry/Farming/ Cultivator	1.203	(0.881, 1.642)	1.094	(0.777, 1.540)
Type of place of residence (ref: Urban)	Rural	1.054	(0.797, 1.393)	0.866	(0.620, 1.210)
Number of household members (ref: ≤ 5 members)	> 5 members	1.030	(0.789, 1.435)	1.021	(0.768, 1.358)
Wealth index (ref: Richest)	Poorest	**1.710***	(1.113, 2.627)	1.439	(0.524, 3.951)
	Poorer	1.549	(0.990, 2.424)	1.459	(0.548, 3.886)
	Middle	1.367	(0.852, 2.193)	1.384	(0.593, 3.229)
	Richer	1.404	(0.890, 2.213)	1.186	(0.664, 2.119)
Household has: television (ref: No)	Yes	0.710	(0.541, 0.931)	0.803	(0.561, 1.150)
Household has: refrigerator (ref: No)	Yes	**0.703***	(0.516, 0.959)	1.039	(0.659, 1.639)
Floor materials (ref: Improved)	Unimproved	1.159	(0.876, 1.534)	0.653	(0.366, 1.164)

Type of cooking fuel (ref: Clean fuel)	Polluted fuel	1.389	(0.968-1.992)	1.098	(0.661, 1.823)
Birth order (ref: Third and so)	First child	0.886	(0.636, 1.233)	0.705	(0.457, 1.088)
	Second child	1.085	(0.786, 1.499)	1.076	(0.754, 1.535)
Stunting status (ref: Stunted)	Normal	0.902	(0.679, 1.198)	0.896	(0.637, 1.260)
Weight for age (ref: Underweight)	Normal	1.018	(0.740, 1.401)	1.119	(0.746, 1.679)
Wasting status (ref: Wasted)	Normal	0.822	(0.525, 1.286)	0.797	(0.486, 1.306)

The bolded values (ORs) indicate the statistical significance.
*p < 0.05; **p < 0.01; ***p < 0.001; OR = Odds Ratio; CI = Confidence Interval.

DISCUSSION

Although Bangladesh met the MDG targets, it still remains among the top 15 countries with high cases of CDD and ARI[7]. Therefore, to ensure that there is a greater understanding of the situation of ARI and CDD in Bangladesh, as well as facilitate its potential to achieve SDG 3.2, we investigated the prevalence of ARI and CDD, and determined the factors that are associated with these two childhood health events. Our study indicates that the prevalence of CDD and ARI was 4.91% and 3.03% respectively, with the prevalence for both outcomes being highest for children born to younger mothers (20-34 years), mothers with no formal education, those in lower socioeconomic status. The ARI prevalence observed reflects a trend of decline in the prevalence of ARI from previous rounds of the BDHS survey reports[7,29,30].

Concerning the factors associated with ARI and CDD, the results of our study show that it was significantly associated with the sex of the child, with male children being at higher risk of ARI or CDD. This finding is in line with earlier studies from Bangladesh[7], Ethiopia[14], Nepal[10], Sudan[31], and Thailand[32] that have reported higher risk of ARI and CDD among male children.. A plausible explanation could be due to higher reporting for male children, which is reinforced by mothers' preference for the male child[33,34]. As such, they are able to notice changes in the health status of the male child early and report to the hospital accordingly.

There is a myriad of evidence suggesting that ARI and CDD are most prevalent in the first two years of a child's life, thus, making children <12 months and those between 12-23 months being at higher risk of ARI or CDD[13,17,35]. Our finding provides confirmation of this association. Moreover, the finding from this study indicates that although the prevalence of ARI and CDD is higher within the first two years of a child's life, the risk of developing ARI or CDD is highest in children between 12-23 months, which supports Sarker et al.[17] findings that the prevalence of

CDD is highest for children aged 1 to 2 years compared to those less than a year old. However, our findings that younger child age is associated with higher prevalence and risk of ARI and CDD could be explained from the point that, the immune system of the child is delicate at that early age, thereby putting them at increased risk of infections[36]. Furthermore, children which such early years tend to be heavily dependent on their mothers and therefore, require appropriate feeding that is proportional to their age[17]. Hence, when mothers slack in their responsibilities to provide safe and appropriate feeding to the children at that age, then their risk of ARI and CDD increases.

We found a significant association between household wealth status and risk of CDD, with children belonging to the poorest household having greater likelihood of developing the diarrheal disease. This corroborates previous related studies from Bangladesh[16,17] and Nepal[10] that also reported higher risk of CDD among children belonging to poor households. This could be justified from the perspective that poorer households have difficulty in meeting their nutritional needs and adopting appropriate feeding practices which may exacerbate their risk of diarrheal infection[10]. This is further iterated in our finding that stunted children had a higher risk of CDD.

Congruent to existing literature[3,11], our study indicates that there is significant association between formal education and ARI, with lower odds of ARI being reported among children whose mothers had formal education compared to those whose mothers had no formal education. A plausible justification for this finding could be that children spend more time with their mothers; therefore, the mother's educational attainment will reflect in the quality of care that they will provide to their child, which may either increase the risk or protection against ARI[37]. Hence, emphasizing the need to promote formal education among women.

Beyond these individual and household factors, we found statistically significant association between geographical region and the risks of ARI and CDD. It was found that children who lived in Rangpur region and Barisal region were at higher risk of developing ARI or CDD. This is consistent with previous studies from Bangladesh[17] that also found similar findings in relation to the regional differences in the prevalence of ARI and CDD. Begum and her colleagues also reported a higher diarrheal prevalence among children < 5 years old in the similar setting and found that water, sanitation and hygiene (WASH) education to the mothers was effective to reduce the burden of diarrhea [38]. According to Sarker et al[17], regions like Barisal are densely populated and is also characterized by the existence of more rivers and water reservoirs that create an enabling environment for diarrheal disease to spread among the population. Perhaps, this could be the reason for the high prevalence of ARI and CDD within the Barisal region.

STRENGTHS AND LIMITATIONS

The strength of this study lies in the use of the most recent nationally representative data for this study which ensures that our findings are generalizable to children in Bangladesh. Also, the study applied appropriate statistical analysis to assess the prevalence and analyze the associated factors concurrently for ARI and CDD. Hence, our findings are valid and reliable. Nevertheless, there were some limitations to our study which noteworthy. First, the use of secondary data that was based on cross-sectional design limits the analysis. As such, causal relationship cannot be ascertained between the outcome and independent variables. The information was self-reported by mothers thereby putting at risk of recall bias. Perhaps, a longitudinal study that seeks to assess the factors that influence CDD and ARI could establish some sort of causality. Notwithstanding, these limitations do not override the validity and reliability of our findings.

CONCLUSION

We also conclude that there are individual, household and geographic factors that exacerbate the risk of ARI and CDD (children born to mothers of younger age, mothers with no formal education, belonging to lower socioeconomic households, being a male child, being stunted, and residing in Barisal and Rangpur regions). Therefore, we recommend that the government of Bangladesh commit resources, policies and interventions geared towards ARI and CDD reduction to the identified at-risk groups. Also, there is the need to augment formal education for women in Bangladesh to accelerate the realization of SDG 3.2, and complete eradication of ARI and CDD related child mortality in the country. Further studies can be conducted to explore how culture also permeates the dynamics of ARI and CDD in Bangladesh, in order to ensure that interventions and policies developed are culturally sensitive to facilitate acceptance and adherence.

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Author contributions

Satyajit Kundu: Conceptualization, methodology, data curation, formal analysis, writing - original draft, final approval; **Subarna Kundu:** Conceptualization, methodology, data curation, formal analysis, writing - original draft, final approval; **Md. Hasan Al Banna**: Writing - original draft; **Bright Opoku Ahinkorah**: Writing - original draft, review and editing, final approval; **Abdul-Aziz Seidu**: Writing - original draft, review and editing; **Joshua Okyere**: Writing - original draft, review and editing.

Competing interests

The authors declared no competing interests.

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Patient consent for publication

Not required.

Ethics approval

The current study used publicly available secondary data provided by Bangladesh demographic and health survey (BDHS) which is collected by following standardized data collection procedures[39]. Procedures and questionnaires for standard DHS surveys have been ethically reviewed and approved by ICF Institutional Review Board (IRB), Maryland, USA. The data is downloaded from the demographic and health survey website for research purposes. Written informed consent from the respondents enrolled in the survey and other ethical review documents are available at: https://dhsprogram.com/methodology/Protecting-the-Privacy-of-DHS-Survey-Respondents.cfm._The data set is available online publicly for all researchers, hence there is no need to approve[39].

Data sharing statement

The study used data from the 2017-2018 Bangladesh Demographic and Health Survey. The data set is available at: https://dhsprogram.com/data/available-datasets.cfm[39].

REFERENCES

1 Apanga PA, Kumbeni MT. Factors associated with diarrhoea and acute respiratory infection

in children under-5 years old in Ghana: an analysis of a national cross-sectional survey. BMC Pediatr 2021;21:1–8.

2 WHO. WHO Global Health Observatory (GHO) data. Causes of child mortality 2015. 2015.

3 Pinzón-Rondón ÁM, Aguilera-Otalvaro P, Zárate-Ardila C, et al. Acute respiratory infection in children from developing nations: a multi-level study. Paediatr Int Child Health 2016;:1–7.

4 Nasanen-Gilmore SPK, Saha S, Rasul I, et al. Household environment and behavioral determinants of respiratory tract infection in infants and young children in northern Bangladesh. Am J Hum Biol 2015;27:851–8.

5 WHO. Ending preventable child deaths from pneumonia and diarrhoea by 2025: the integrated Global Action Plan for Pneumonia and Diarrhoea (GAPPD). 2013.

6 Dewey KG, Mayers DR. Early child growth: how do nutrition and infection interact? Matern Child Nutr 2011;7:129–42.

7 Sultana M, Sarker AR, Sheikh N, et al. Prevalence, determinants and health care-seeking behavior of childhood acute respiratory tract infections in Bangladesh. PLoS One 2019;14:e0210433.

8 Kabir AL, Amin MR, Mollah MAH, et al. Respiratory disorders in under-five children attending different hospitals of Bangladesh: A cross sectional survey. J Respir Med Res Treat 2016;11:2016–183615.

9 Gebru T, Taha M, Kassahun W. Risk factors of diarrhoeal disease in under-five children among health extension model and non-model families in Sheko district rural community, Southwest Ethiopia: comparative cross-sectional study. BMC Public Health 2014;14:1–6.

10 Budhathoki SS, Bhattachan M, Yadav AK, et al. Eco-social and behavioural determinants of diarrhoea in under-five children of Nepal: a framework analysis of the existing literature. Trop Med Health 2016;44:1–7.

11 Bbaale E. Determinants of diarrhoea and acute respiratory infection among under-fives in Uganda. Australas Med J 2011;4:400.

12 Lee H-Y, Huy N Van, Choi S. Determinants of early childhood morbidity and proper treatment responses in Vietnam: results from the Multiple Indicator Cluster Surveys, 2000–2011. Glob Health Action 2016;9:29304.

13 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 J Prev Med 2013;3:446.

14 Anteneh ZA, Andargie K, Tarekegn M. Prevalence and determinants of acute diarrhea among children younger than five years old in Jabithennan District, Northwest Ethiopia, 2014. BMC Public Health 2017;17:1–8.

15 Amugsi DA, Aborigo RA, Oduro AR, et al. Socio-demographic and environmental determinants of infectious disease morbidity in children under 5 years in Ghana. Glob Health Action 2015;8:29349.

16 Kamal MM, Hasan MM, Davey R. Determinants of childhood morbidity in Bangladesh: evidence from the demographic and health survey 2011. BMJ Open 2015;5:e007538.

17 Sarker AR, Sultana M, Mahumud RA, et al. Prevalence and health care–seeking behavior for childhood diarrheal disease in Bangladesh. Glob Pediatr Heal 2016;3:2333794X16680901.

18 NIPORT and ICF. Mitra and associates. Dhaka, Bangladesh: ICF International. Bangladesh Demographic and Health Survey 2017-18. Dhaka, Bangladesh, and Rockville, Maryland, USA: NIPORT and ICF: 2020. https://dhsprogram.com/pubs/pdf/fr265/fr265.pdf

19 WHO. 2018 Global reference list of 100 core health indicators (plus health-related SDGs). World Health Organization 2018.

20 Forsberg BC, Petzold MG, Tomson G, et al. Diarrhoea case management in low-and middle-income countries: an unfinished agenda. Bull World Health Organ 2007;85:42–8.

21 Mulatya DM, Mutuku FW. Assessing Comorbidity of Diarrhea and Acute Respiratory Infections in Children Under 5 Years: Evidence From Kenya's Demographic Health Survey 2014. J Prim Care Community Health 2020;11:2150132720925190.

22 Imran MIK, Inshafi MUA, Sheikh R, et al. Risk factors for acute respiratory infection in children younger than five years in Bangladesh. Public Health 2019;173:112–9.

23 WHO. WHO child growth standards: length/height-for-age, weight-for-age, weight-for-length, weight-for-height and body mass index-for-age: methods and development. World Health Organization 2006.

24 WHO. Progress on drinking water, sanitation and hygiene: 2017 update and SDG baselines. 2017.

25 WHO. Safely managed drinking water: thematic report on drinking water 2017. 2017.

26 Rehfuess E, WHO. Fuel for life: household energy and health. World Health Organization 2006.

27 ICF. Demographic and Health Surveys Standard Recode Manual for DHS7. The Demographic and Health Surveys Program. Rockville, Maryland, U.S.A.: ICF. 2018. https://dhsprogram.com/pubs/pdf/DHSG4/Recode7_DHS_10Sep2018_DHSG4.pdf

28 Adebowale SA, Morakinyo OM, Ana GR. Housing materials as predictors of under-five mortality in Nigeria: evidence from 2013 demographic and health survey. BMC Pediatr 2017;17:1–13.

29 NIPORT M and A (Firm) & MI. Bangladesh Demographic and Health Survey, 2007. NIPORT 2009.

30 NIPORT M and A (Firm) & MII for RD. Bangladesh demographic and health survey. National Institute of Population Research and Training (NIPORT) 2011.

31 Siziya S, Muula AS, Rudatsikira E. Correlates of diarrhoea among children below the age of 5 years in Sudan. Afr Health Sci 2013;13:376–83.

32 Hasan R, Rhodes J, Thamthitiwat S, et al. Incidence and etiology of acute lower respiratory tract infections in hospitalized children younger than 5 years in rural Thailand. Pediatr Infect Dis J 2014;33:e45.

33 Vlassoff C. Gender differences in determinants and consequences of health and illness. J Health Popul Nutr 2007;25:47.

34 Cox M, Rose L, Kalua K, et al. The prevalence and risk factors for acute respiratory infections in children aged 0-59 months in rural Malawi: A cross-sectional study. Influenza Other Respi Viruses 2017;11:489–96. doi:10.1111/irv.12481

35 Murray CJL, Vos T, Lozano R, et al. Disability-adjusted life years (DALYs) for 291 diseases and injuries in 21 regions, 1990–2010: a systematic analysis for the Global Burden of Disease Study 2010. Lancet 2012;380:2197–223.

36 Walke SP, Das R, Acharya AS, et al. Incidence, pattern, and severity of acute respiratory infections among infants and toddlers of a peri-urban area of Delhi: a 12-month prospective study. Int Sch Res Not 2014;2014.

37 Tazinya AA, Halle-Ekane GE, Mbuagbaw LT, et al. Risk factors for acute respiratory infections in children under five years attending the Bamenda Regional Hospital in Cameroon. BMC Pulm Med 2018;18:1–8.

38 Begum MR, Al Banna M, Akter S, et al. Effectiveness of WASH Education to Prevent Diarrhea among Children under five in a Community of Patuakhali, Bangladesh. SN Compr Clin Med 2020;2:1158–62.

[dataset] 39 National Institute of Population Research and Training (NIPORT) M and A and II. Bangladesh Demographic and Health Survey 2017-18. Data Extract from BDKR7RFL.SAV. Bangladesh Demographic and Health Surveys (BDHS), Version 7, BDHS and ICF [Distributors]. 2020. https://dhsprogram.com/data/available-datasets.cfm (accessed 4 Oct 2021).

Figure captions:

Figure 1. Flow chart for the participants selection

Figure 2. Division-wise distribution of prevalence (weighted) of diarrheal disease among children under five years old in Bangladeshi

Figure 3. Division-wise distribution of prevalence (weighted) of acute respiratory infection among children under five years old in Bangladesh

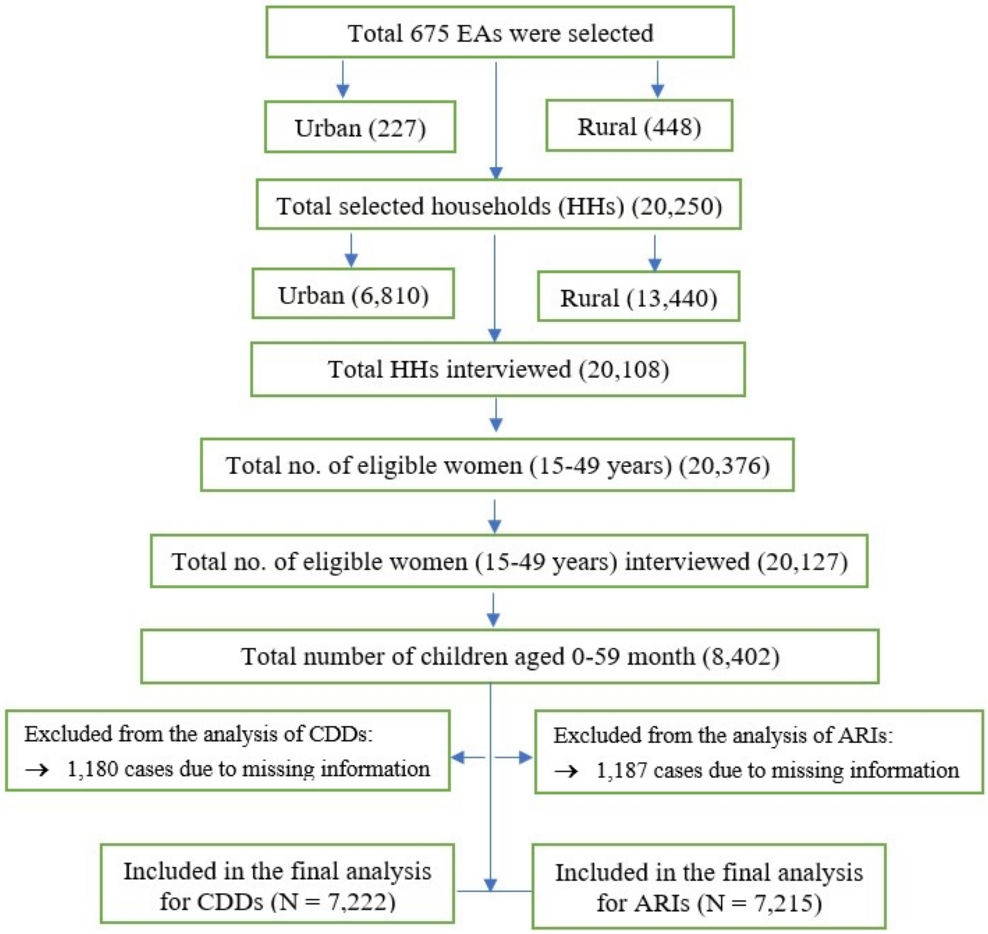

Figure 1. Flow chart for the participant selection

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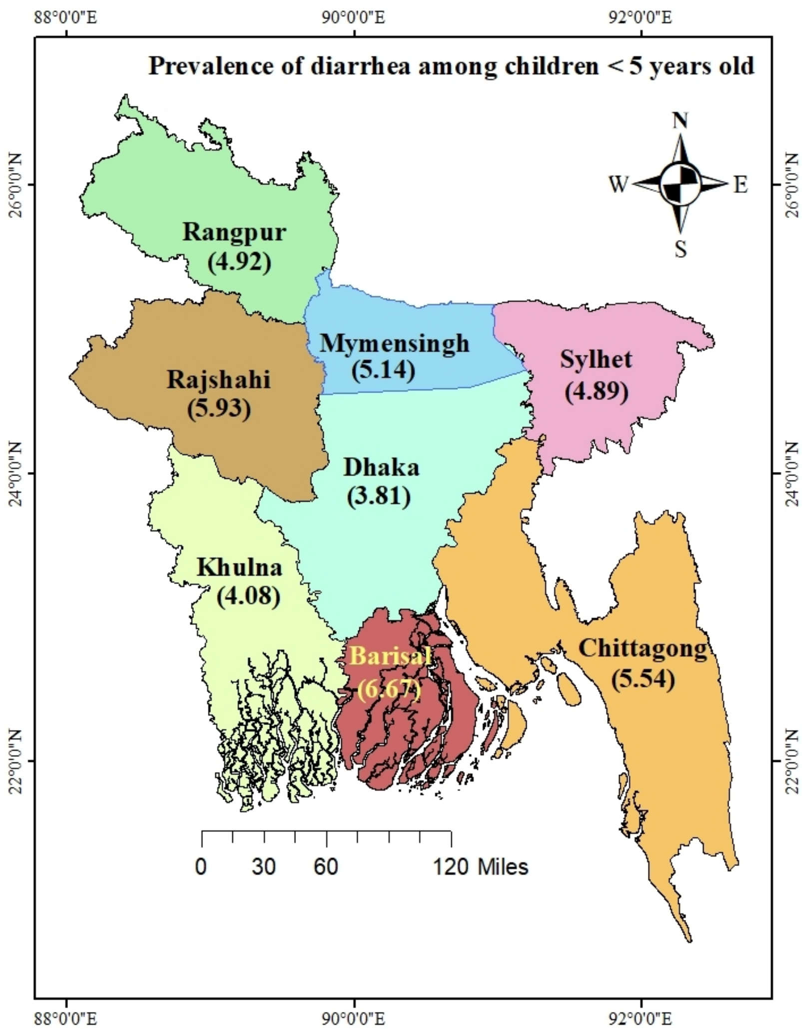

Figure 2. Division-wise distribution of prevalence (weighted) of diarrheal disease among children under five years old in Bangladeshi

215x279mm (96 x 96 DPI)

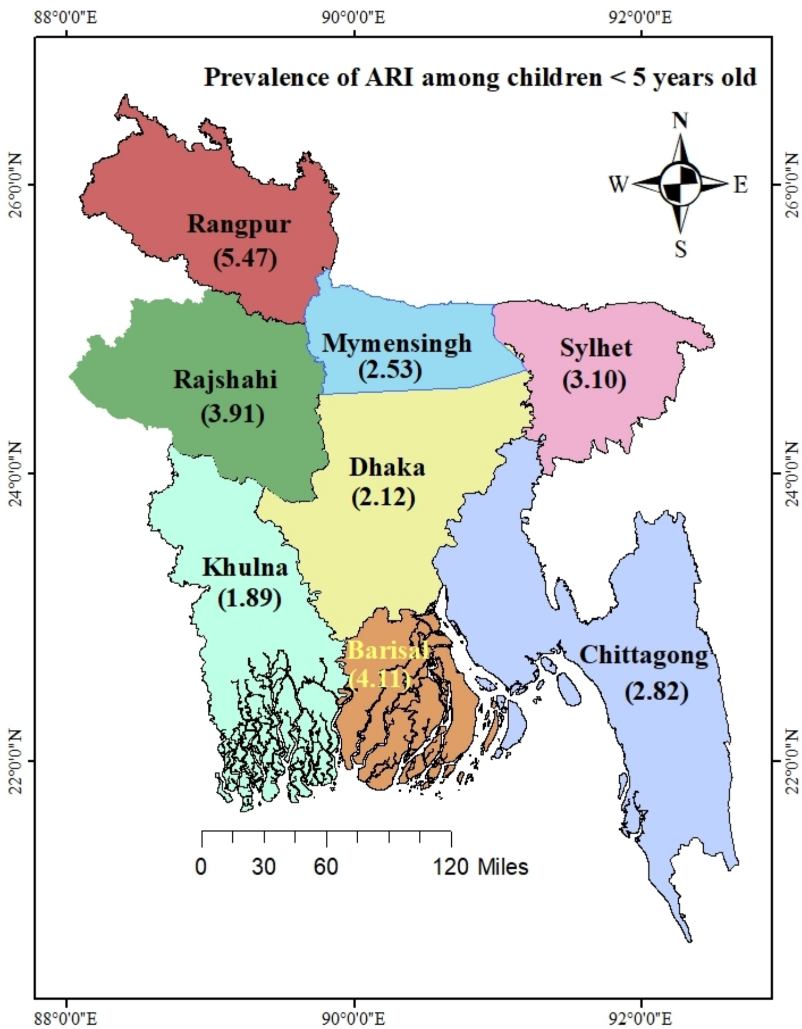

Figure 3. Division-wise distribution of prevalence (weighted) of acute respiratory infection among children under five years old in Bangladesh

215x279mm (96 x 96 DPI)

STROBE 2007 (v4) Statement—Checklist of items that should be included in reports of *cross-sectional studies*

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	Page 2
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	Page 2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	Page 3 to 4
Objectives	3	State specific objectives, including any prespecified hypotheses	Page 4
Methods			
Study design	4	Present key elements of study design early in the paper	Page 5
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	Page 5
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	Page 5
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	Page 5 to 7
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	Page 7
Bias	9	Describe any efforts to address potential sources of bias	Page 5
Study size	10	Explain how the study size was arrived at	Page 5
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	Page 5 to 7
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	Page 7
		(*b*) Describe any methods used to examine subgroups and interactions	Page 7
		(*c*) Explain how missing data were addressed	Page 5
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	Not applicable
		(*e*) Describe any sensitivity analyses	Page 7
Results			

Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	Page 8
		(b) Give reasons for non-participation at each stage	Not applicable
		(c) Consider use of a flow diagram	Not applicable
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	Page 8
		(b) Indicate number of participants with missing data for each variable of interest	Not applicable
Outcome data	15*	Report numbers of outcome events or summary measures	Not applicable
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	Page 12 to 14
		(*b*) Report category boundaries when continuous variables were categorized	Page 12 to 14
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	Not applicable
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	Not applicable
Discussion			
Key results	18	Summarise key results with reference to study objectives	Page 15
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	Page 3
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	Page 15 to 17
Generalisability	21	Discuss the generalisability (external validity) of the study results	Page 17
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	Page 18

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.