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Risk factors for acute respiratory infection in children younger than five years in Bangladesh

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ABSTRACT

Objectives: Acute respiratory infections (ARIs) are one of the major causes of child morbidity and mortality in the developing world. There is a lack of information regarding ARIs in children in Bangladesh. The study aims to determine the potential risk factors that are associated with ARIs among children younger than 5 years in Bangladesh.
Study design: A cross-sectional study design was used.
Methods: Data were retrieved from the 2014 Bangladesh Demographic and Health Survey, which provides data for monitoring indicators in population, health and nutrition. In total, 7032 children (weighted) younger than 5 years were eligible for our analysis. Children with a cough and chest-related short, rapid breathing in the 2 weeks before the survey were considered having an ARI. A binary logistic regression model was used to determine the significant risk factors.
Results: The prevalence of ARI was 5.3% (95% confidence interval [CI]: 4.7–6.0) in the sample population. Infants aged 0–11 months (odds ratio [OR] = 2.87, 95% CI: 1.92–4.28), toddlers aged 12–23 months (OR = 2.03, 95% CI: 1.21–3.38) and children aged 24–35 months (OR = 1.67, 95% CI: 1.11–2.50) had a greater risk of ARI than older children. Children of lower economic (OR = 2.03, 95% CI: 1.27–3.27) and middle economic (OR = 1.67, 95% CI: 1.06–2.64) families were also at a higher risk of ARI. Girls (OR = 0.75, 95% CI: 0.56–0.99) had a lower risk of ARI compared with boys. In addition, stunting or slow growth rate in children (OR = 1.42, 95% CI: 1.02–1.97) was significantly associated with ARI.
Conclusion: Young children, boys and stunted children are at greater risk of ARI. Educating mothers on the nutritional needs of children and subsequently reducing stunting due to malnutrition would help in the effort to reduce child morbidity and mortality caused by ARI.

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Introduction

Acute respiratory infections (ARIs) are classified as upper respiratory tract infections (URIs) and lower respiratory tract infections (LRIs).[1] URIs are the most common illness in young children; however, URIs are seldom life-threatening in contrast to LRIs, such as pneumonia, influenza and bronchiolitis, which are the leading contributors to mortality from ARIs.[2–4] In 2010, ARIs were responsible for approximately 5.8 million deaths worldwide.[5] According to the United Nations International Children's Emergency Fund, pneumonia caused nearly 16% of the 5.6 million deaths in children younger than 5 years (also referred to as ‘under-five’) in 2016, resulting in 6 deaths per 1000 live births globally. ARIs account for the deaths of approximately 2400 under-five children a day. In South Asian countries, such as Sri Lanka, India and Bangladesh, the under-five death rate due to ARI was 6%, 15% and 16%, respectively.[6] Another study estimated that 40% of the global ARI mortality is seen in Bangladesh, India, Indonesia and Nepal alone.[7]

According to the World Health Organization (WHO), the mortality and burden caused by ARIs in developing countries are 10 and 50 times higher, respectively, than those in developed countries.[8] Moreover, in 1999, the WHO also reported that nearly one-fifth of the 11.6 million under-five deaths were caused as a result of ARI-related conditions in developing countries each year.[9] In Bangladesh, pneumonia is the single largest cause of under-five mortality, resulting in around 50,000 deaths every year (approximately 28% of child deaths).[10] Around 80,000 children with virus-related ARIs are admitted to hospitals each year, although the total number of infections is estimated to be much higher.[10] Unfortunately, many severe LRIs do not respond to treatment because of the lack of highly effective antiviral drugs;[1] therefore, identifying the risk factors for ARI is crucial.

In Bangladesh, there are few studies on ARIs. Previous studies that were conducted based on the 2004 Bangladesh Demographic and Health Survey (BDHS) investigated the risk factors of ARI among under-five children.[2,11] Another study, using the 2003 Multiple Indicator Cluster Survey data, investigated the association between prevalence of breastfeeding and morbidity due to diarrhoeal diseases and ARI among infants aged 0–3 months.[12] These studies used the data sets from 2003 to 2004, which are now obsolete. The most recent research was from the 2011 BDHS, which investigated infectious diseases resulting in childhood morbidity.[13] However, over the past decade, in Bangladesh, the adult literacy rate has risen to 72.9%,[14] poverty has decreased and there has been commendable progress in decreasing hunger. The child mortality rate has also decreased as a result of improving maternal and child healthcare facilities.[15] Therefore, because of the increase in socio-economic and living standards in Bangladesh, we aimed to investigate whether the factors found in previous studies are still associated with ARIs and whether any new factors have emerged over recent years.

Methods

Study area

Bangladesh is one of the world's most densely populated countries and has widespread poverty.[16] Most of the land is low and flat, consisting of alluvial soil. Seasonal monsoons dominate the tropical climate in Bangladesh, with mild winters and hot humid summers. Bangladesh has a mean elevation of 85 m above sea level, and the fertile delta is often subjected to natural disasters, such as floods, cyclones, tidal bores and drought.[17,18]

Study design

We used a nationally representative data set from the 2014 BDHS. The BDHS uses stratified random sampling, selected in two stages. First, 600 enumeration areas (EAs) were selected with probability proportional to the size of the EA, consisting of 207 urban and 393 rural EAs. Second, systemic sampling of 17,989 households was carried out, and 17,300 households were successfully interviewed. In total, 17,863 married women aged 15–49 years were interviewed, and mothers of 7886 children younger than 5 years were questioned about pregnancy, postnatal care, immunisation and health issues, including ARI symptoms. A final data set of 7032 (weighted) observations was obtained, after excluding non-eligible cases (e.g. visitors and non-surviving children) and observations with missing information on the child's age. The sampling procedure is represented in Fig. S1 (see Supplementary Material). A detail description of the sample design and procedure is presented in the 2014 BDHS report.[17]

Outcome variable

The outcome variable was ARI. A child was identified as suffering from ARI if his/her mother reported that the child had a cough accompanied by chest-related short, rapid breathing in the 2 weeks before the survey.

Predictor variables

In this study, child's age, sex, birth order, place of delivery, weight at birth, delivery by caesarean section, season of birth, medication received for intestinal parasites, vitamin A supplementation, nutritional status (stunting and wasting), place of residence, region of the country, media accessibility (possession of television or radio), source of drinking water, toilet facility, type of cooking fuel, wealth index, having a health card (vaccination), mother's age, mother's educational level, mother's body mass index (BMI), number of living children and pregnancy complications were assumed as possible predictor variables of ARI.

For measuring a child's nutritional status, two anthropometric indices, height-for-age and weight-for-height z score, were used as recommended by the WHO.[19] The z score implies how many standard deviations a given value is apart from the mean, and it is usually used to standardise data. In this particular case, the z score was used to compare stunting and wasting across gender and all age groups of under-five children. A child was considered wasted if the weight-for-height z score was less than −2 and stunted if the height-for-age z-score was less than −2. Some of the variables were recategorised by combining two or more levels of individual variables.

Cooking fuel was categorised into biomass fuel (electricity, liquefied petroleum gas, natural gas, biogas, kerosene, coal and lignite) and fossil fuel (charcoal, wood, straw/shrubs/grass, agricultural crop and animal dung). Toilet facilities were categorised into improved (flush toilet, flush to piped sewer system, flush to septic tank, flush to pit latrine, pit latrine with slab and ventilated improved pit latrine), shared (improved but shared with other households) and not improved (e.g. hanging toilet, open pit). The source of drinking water was classified as piped water (piped water, piped into a dwelling, piped to yard/plot, public tap/standpipe), tube well (tube well water, tube well or borehole) and other (e.g. rainwater, river, protected or unprotected well). Mother's educational level was also divided into three groups: no education, primary and secondary complete or higher (completing at least grade 10). Wealth index was recategorised into high economic class (upper 20% asset value), middle economic class (middle 40% asset value) and low economic class (lower 40% asset value). Mother's BMI was classified as underweight (BMI less than 18.5 kg/m^2), normal (BMI 18.5–24.9 kg/m^2), overweight (BMI 25–29.9 kg/m^2) and obese (BMI higher than 30 kg/m^2).[20]

Statistical analyses

We used the logit transformation method to obtain 95% confidence intervals (CIs) of ARI prevalence. The relationship between ARI and every other considered risk factor was investigated individually by using bivariate analysis, mainly the Chi-squared test and bivariate logistic regression model. We used the multivariable logistic regression model to observe how one risk factor acts when the effect of all other risk factors associated with ARI are adjusted. The multivariable logistic regression model was formed by the backward elimination process to identify significant risk factors of ARI. Considering cluster variation in our analysis, we fitted a multilevel model using the survey binary logistic regression model. The statistical analyses and data management for this study had been carried out using R (survey package) and SPSS (IBM SPSS 22).

Variable selection

Variables were selected in two stages. In the first stage, the Rao-Scott Chi-squared test (a design-adjusted version of the Pearson Chi-squared test)[21] was carried out because it takes into account the cluster-design effect of the data. In total, 13 variables were significant with ARI at the 20% significance level (Table 1). In the second stage, bivariate logistic regression was conducted separately for each of the 13 variables selected from the first stage, and their unadjusted odds ratio (OR) was examined (Table S1). In this stage, eight variables were found to be significant at the 5% significance level.

A multivariable full model was formed with the selected predictor variables. Then, a manual stepwise backward elimination procedure was performed to obtain the final model. At each step in the stepwise elimination process, the least significant variable was excluded, and this process was continued until all the variables in the model were significant at the 5% significance level. To ensure the final model was correctly specified, we repeated the backward elimination process by adding all the risk factors in the full model, and variables were reserved in the model only if P was < 0.05. Risk factors selected by the second approach were the same as the initial approach.

We used the variance inflation factor (VIF) value to examine multicollinearity in the final model with a cut-off value of 4.00 (Table S2). To check the predictive accuracy of the final model, the area under the curve (AUC) of the receiver operating characteristic curve was used (Fig. S2). We also used the Hosmer and Lemeshow goodness-of-fit test to provide an overview of the overall fit of the final model.

Results

In total, 7032 children (3683 male and 3349 female) younger than 5 years were included in the final sample. Most of them (74.1%) lived in rural areas. As for demographic characteristics, 83.8% of respondents used biomass fuel, 66.4% had either an improved or shared toilet facility, 56% reported media unavailability and 62.7% of children did not take medicines for intestinal parasites (Table 1).

The prevalence of ARI was 5.3% (95% CI: 4.7–6.0) in the sample population. Fig. 1 shows that ARI prevalence decreased with increasing age, and in most of the age groups, boys had a higher prevalence of ARI than girls. Fig. 2 demonstrates that children of lower and middle economic families were more vulnerable to ARI with 6.57% and 5.14% prevalence, respectively, compared with 3.09% for those belonging to the higher economic class. Fig. 3 shows that children in the Rajshahi and Sylhet regions of Bangladesh had the highest prevalence, whereas the lowest prevalence was seen in Barisal. The results of the Rao-Scott Chi-squared independence test (Table 1) suggest that the prevalence of ARI was significantly associated ($P < 0.20$) with child's age, sex, stunting, wasting, wealth status, place of residence, mother's age group, mother's educational level and mother's BMI. Toilet facility, type of cooking fuel, access to media and taking medications for intestinal parasites were marginally associated with ARI (Table 1).

The VIF value showed no multicollinearity in the final multivariable logistic model (Table S2). In Fig. S2, the AUC value of 0.61 suggests that the classification accuracy is fairly good. Moreover, the Hosmer and Lemeshow goodness-of-fit test (value = 4.678, degrees of freedom = 6, P-value = 0.585) did not find any lack of fit in the model.

Age, sex, stunting and wealth status were the significant factors for ARI in the final model (Table 2). For example, infants aged 0–11 months (OR = 2.87, 95% CI: 1.92–4.28) and toddlers aged 12–23 months (OR = 2.03, 95% CI: 1.21–3.38) had 2.87 and 2.03 times higher odds of experiencing ARI, respectively, than older children. Children aged 24–35 months (OR = 1.67, 95% CI: 1.11–2.50) also had 1.67 times higher odds

Table 1 – Frequency distribution (weighted[a]) and acute respiratory infection (ARI) prevalence in Bangladesh among children younger than 5 years.

Variable	ARI [n (%)]		Total [n (%)]	Chi-squared test (P-value)
	Yes	No		
Child's age group in months				
0–11	104 (27.6)	1184 (17.8)	1287 (18.3)	
12–23	97 (25.9)	1381 (20.7)	1478 (21.0)	<0.01
24–35	75 (20.0)	1357 (20.4)	1432 (20.4)	
36–47	55 (14.6)	1356 (20.4)	1411 (20.1)	
48–59	45 (11.9)	1380 (20.7)	1424 (20.3)	
Sex				
Male	222 (59.2)	3461 (52.0)	3683 (52.4)	
Female	153 (40.8)	3196 (48.0)	3349 (47.6)	0.03
Stunting				
Yes	155 (43.5)	2236 (36.0)	2391 (36.4)	
No	201 (56.5)	3975 (64.0)	4176 (63.6)	0.03
Wasting				
Yes	63 (17.7)	882 (14.2)	945 (14.4)	
No	293 (82.3)	5328 (85.8)	5621 (85.6)	0.12
Medication for intestinal parasites				
Yes	98 (26.4)	2519 (37.9)	2617 (37.3)	
No	275 (73.6)	4129 (62.1)	4404 (62.7)	<0.01
Educational level (mother)				
No education	52 (13.9)	1162 (17.5)	1214 (17.3)	
Primary	143 (38.1)	1821 (27.4)	1964 (27.9)	0.01
Secondary or higher	179 (47.7)	3674 (55.2)	3853 (54.8)	
Mother's age group in years				
15–24	203 (54.1)	3092 (46.5)	3296 (46.9)	
25-34	142 (37.9)	3019 (45.3)	3161 (45.0)	0.09
35-44	28 (7.6)	510 (7.7)	538 (7.7)	
45+	1 (0.3)	36 (0.5)	37 (0.5)	
Body mass index (mother)				
Underweight	107 (28.6)	1408 (21.3)	1515 (21.7)	
Normal weight	214 (57.3)	3919 (59.4)	4133 (59.2)	0.02
Overweight	39 (10.3)	1026 (15.5)	1065 (15.3)	
Obese	14 (3.8)	250 (3.8)	264 (3.8)	
Place of residence				
Urban	77 (20.5)	1745 (26.2)	1823 (25.9)	
Rural	298 (79.5)	4911 (73.8)	5210 (74.1)	0.05
Wealth index				
Lower economic class	193 (51.5)	2745 (41.2)	2938 (41.8)	
Middle economic class	140 (37.3)	2587 (38.9)	2728 (38.8)	0.01
Higher economic class	42 (11.2)	1324 (19.9)	1366 (19.4)	
Toilet facilities				
Improved	135 (36.1)	2884 (43.3)	3019 (42.9)	
Shared	96 (25.5)	1556 (23.4)	1652 (23.5)	0.17
Not improved	144 (38.4)	2216 (33.3)	2360 (33.6)	
Type of cooking fuel				
Fossil fuel	44 (11.7)	1096 (16.5)	1140 (16.2)	
Biomass fuel	332 (88.3)	5546 (83.5)	5878 (83.8)	0.06
Access to mass media (mother)				
Yes	131 (34.9)	2973 (44.7)	3104 (44.1)	
No	244 (65.1)	3684 (55.3)	3928 (55.9)	0.01
Total	375 (5.3)	6657 (94.7)	7032	

[a] Frequencies are weighted using sample weight.

of ARI compared with children aged 48–59 months; however, by the age of 36–47 months, the difference was not significant (OR = 1.27, 95% CI: 0.80–2.01). Girls had 25% lower odds (OR = 0.75, 95% CI: 0.56–0.99) of ARI than boys. Children with stunted or impaired growth had 1.42 (OR = 1.42, 95% CI: 1.02–1.97) times higher odds of being affected by ARI compared with those with normal height for age. As for wealth status, children from lower economic (OR = 2.03, 95% CI: 1.27–3.27) and middle economic (OR = 1.67, 95% CI: 1.06–2.64) families had 2.03 and 1.67 times higher odds, respectively, of having ARI compared with those from higher economic families.

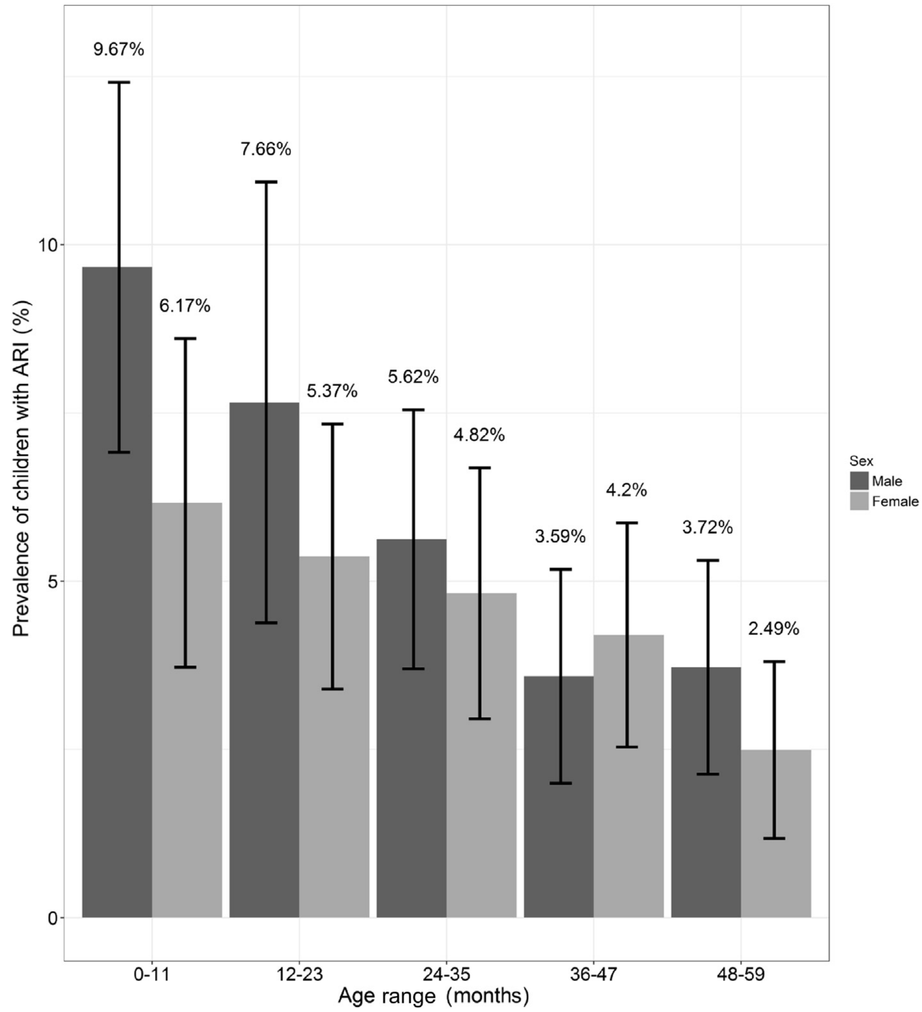

Fig. 1 – Age- and sex-specific prevalence of acute respiratory infection (ARI) among under-five children in Bangladesh, 2014 (error bar denotes 95% confidence intervals).

Discussion

We found that the prevalence of ARI was 5.3% in the sample population. That is, approximately one in every 20 children had ARI, which is similar to the 2014 BDHS final report.[17] A previous study conducted in Bangladesh showed that the prevalence of ARI was 21.3%,[11] and another study showed the prevalence of ARI was 31.2% among infants aged 0–3 months.[12] The results of the present study indicate that, nearly a decade later, there has been a reduction in ARIs, which is in agreement with a study that showed under-five mortality due to ARI decreased from 20.1% to 16% between 2000 and 2016 .[22]

Age was divided into five groups to explore ARI prevalence at each childhood stage. It was found that, along with infants and toddlers, 2-year-old children also had a high prevalence of ARI. The risk of ARI then decreases with the age. This is in line with an earlier study conducted in Iraq and is an extension to the findings of previous studies from Bangladesh and India with three age groups, where infants and toddlers were shown to be the most vulnerable groups.[2,11,23–25] The lack of protective immunity among children younger than 4 years could be a reason for these findings.[23] The results emphasise the fact that a child's health during the first 3 years of life requires special attention.

We also found that boys were significantly at more risk of ARI than girls. This finding is in line with the studies from Bangladesh and Iraq.[2,23]

Children who had stunting due to malnutrition more frequently experienced ARIs, which is similar to the results seen in a previous study conducted in Bangladesh.[11]

Mother's education was associated with ARI in the bivariate analysis but was not significant in the final model. Recent studies from Bangladesh and India also had the same observation.[7,13] This is in contrast to earlier studies that found maternal education to be a key factor for ARI prevalence.[2,11] However, it is important to note that over the past decade, Bangladesh has made an impressive progress in achieving a high literacy rate. According to the final report of the 2017 Bangladesh Sample Vital Statistics, the adult literacy rate in 2017 was 72.9% compared with 53.5% in 2005, and the literacy rate for women was 70.1% in 2017 and 48.6% and 2005.[14] These results clearly indicate the increase in literacy over this time

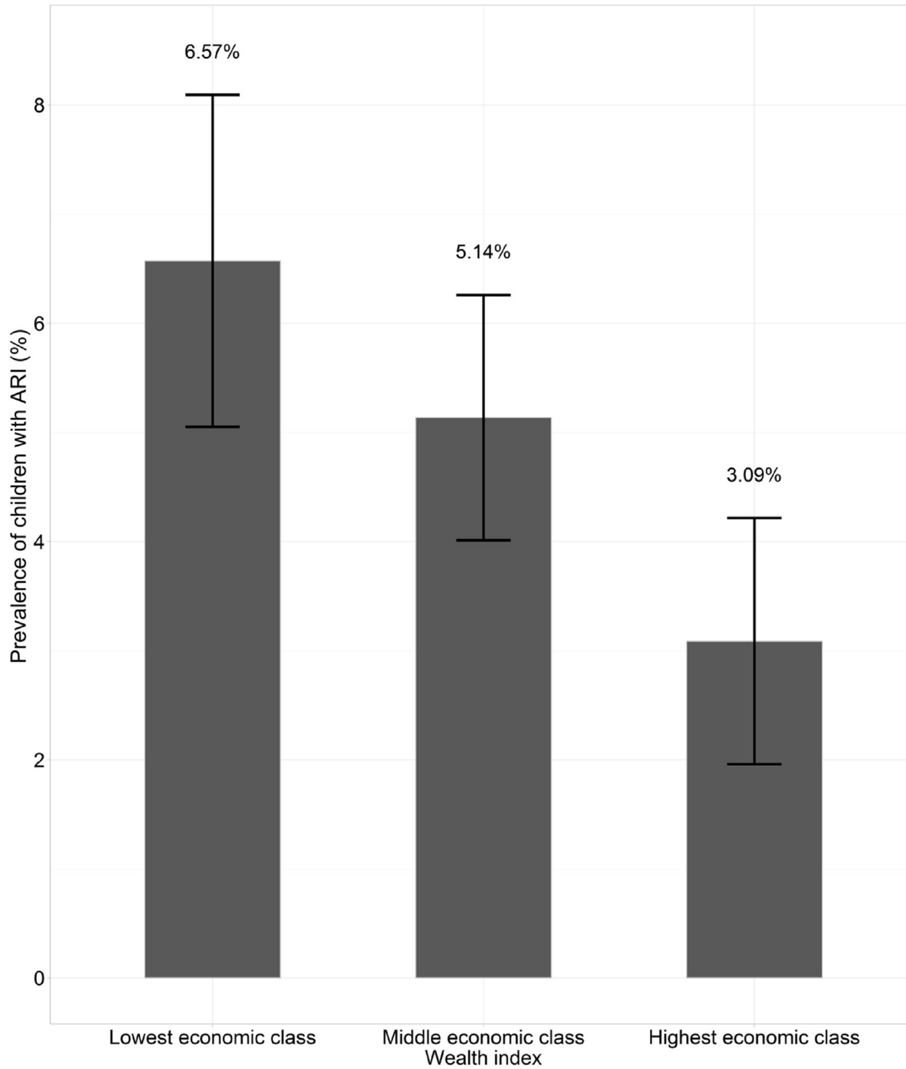

Fig. 2 – Prevalence of acute respiratory infection (ARI) among under-five children according to the wealth index in Bangladesh, 2014 (error bar denotes 95% confidence intervals).

period. Moreover, non–government organisations working with the microcredit system play a vital role in spreading maternal and child health–related knowledge, especially among poor and illiterate women, through mass media, clinical and community-based interventions and focus group discussions. Effective use of community-based methods in promoting health-related knowledge has been reported previously.[26] Therefore, nowadays, women living in both rural and urban areas are more aware of health-related issues, and this could be the possible reason for mother's education no longer being a significant risk factor of ARI.

Taking drugs for intestinal parasites showed an association with ARI but was also shown to be insignificant in the final model. The most common intestinal helminthic parasite is *Ascaris lumbricoides*,[27] and it is common in areas where unhygienic sanitation and faecal contamination of soil or food exists.[28] *Ascaris* larvae are responsible for Loeffler's syndrome, which can lead to *Ascaris* pneumonia, an acute lower respiratory tract disorder.[29] Bangladesh has achieved tremendous progress in reducing open air defaecation, and the current improved sanitation rate is 61%.[30] Thus, the increased practices of hygiene may have resulted in medicines for intestinal parasites not being a risk factor for ARI.

Our analyses also revealed that children of lower socio-economic families suffered more frequently from ARIs compared with those children belonging to wealthy families. Previous studies have also reported lower socio-economic status to be a significant risk factor, suggesting that wealth status is a crucial factor behind ARI.[2,11,24,31] The reason behind this could be because poor families cannot afford a healthy cooking system, hygienic toilets or a safe water source, they do not have a television or radio and they are barely able to provide nutritional food to their children. When the wealth index is included in the final model, other variables related to it, such as toilet facilities, type of cooking fuel, the source of water and accessibility to mass media (possession of television and radio), did not appear as significant risk factors because they explain the same variability.

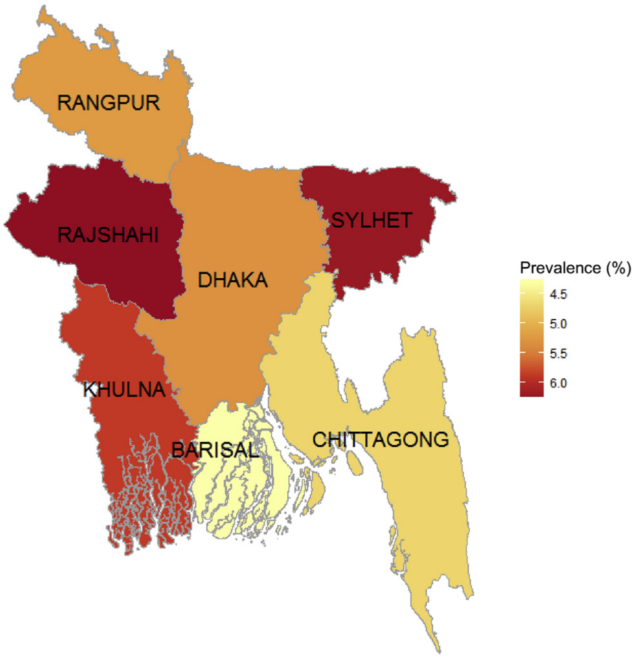

Fig. 3 – Prevalence of acute respiratory infection (ARI) in different regions of Bangladesh.

Table 2 – Risk factors for acute respiratory infections and their odds ratio obtained from the multivariable logistic model.

Variable		Odds ratio	95% confidence interval	
			Lower	Upper
Age of children in months	0–11	2.87	1.92	4.28
	12–23	2.03	1.21	3.38
	24–35	1.67	1.11	2.50
	36–47	1.27	0.80	2.01
	48–59	1.00[a]		
Sex of children	Female	0.75	0.56	0.99
	Male	1.00[a]		
Stunting	Yes	1.42	1.02	1.97
	No	1.00[a]		
Wealth index	Lower economic class	2.03	1.27	3.27
	Middle economic class	1.67	1.06	2.64
	Higher economic class	1.00[a]		

[a] Indicates the reference group.

Our study has some remarkable strengths. First, we used the latest available nationally representative sample data from the 2014 BDHS. Second, we used survey binary logistic regression for analysing the data, which takes cluster variation into account, thus ensuring that the standard errors of coefficients have been accurately estimated. Third, we have assessed some new potential risks factors (e.g. media accessibility, child's weight at birth, delivery by caesarean section and season of birth), assuming that these variables might currently have an influence on the prevalence of ARI in Bangladesh; however, they were not statistically significant.

Vitamin D supplementation was not included in the BDHS 2014 data set, although a previous study showed that it was a significant risk factor for ARI.[32] It would also be interesting to understand the impact of geography and climate change on ARI, but there are no data available on these areas in the 2014 BDHS.

Based on the findings of this study, we recommend that the nutritional status of young children, especially infants, should be prioritised as they were the most vulnerable group. Mothers are generally assumed to be the most involved individuals in their child's health; therefore, they can play an important role by taking precautionary measures when provided with proper education and health-related knowledge. A community healthcare team can be formed to promote childcare, nutrition and sanitation and to deliver drug supplementation to children in rural and poor communities to help reduce ARI prevalence.

In conclusion, we did not observe any new factors causing ARI (e.g. pneumonia) . We also observed that the prevalence of ARI has decreased over recent years, which highlights the improvements made in child health in Bangladesh. We observed that boys were more prone to ARIs than girls. In addition, children's age, stunting caused by malnutrition and family economic status were significant risk factors for ARI.

Author statements

Ethical approval

BDHSs received ethical approval from the ICF Macro Institutional Review Board, Maryland, USA, and the National Research Ethics Committee of the Bangladesh Medical Research Council (BMRC), Dhaka, Bangladesh.

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Competing interests

None.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.puhe.2019.05.011.