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Title Page

Association of household fuel usage with acute respiratory illness among children under five years in Bangladesh

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Research article

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Abstract

Aim: The most common cause of death among Bangladeshi children under the age of five is acute respiratory infection (ARI). For cooking, low-income families frequently rely on wood, coal, and animal excrement. It's unclear whether using alternative fuels offers a health benefit over solid fuels. Therefore, we aim to conduct a study to detect the effects of fuel usage on ARI in children. **Materials and Methods:** Using the Bangladesh Demographic & Health Survey (BDHS) 2017-18 data, we estimated the effects of fuel use on ARI by constructing logistic regression models. The risk factors for ARI due to fuel use were assessed using a multivariable logistic regression model. **Results:** From the analysis, we found the crude (the only type of fuel in the model) odds ratios (OR) for the ARI were 1.693 (95% confidence interval (CI): 1.058-2.709). This suggests that children in families using contaminated fuels were 69.3% more likely than children in households using clean fuels to experience an ARI episode. After adjusting for cooking fuel, type of roof material, child's age (months), and sex of the child, the effect of solid fuels was also more acute as the adjusted odds ratio (AOR) for the ARI was 1.692 (95% CI: 1.053-2.718) or when compared to the effect of clean fuel, an ARI occurrence is 69.2% more likely. **Conclusion:** The study has found a significant association between the use of solid fuels and the presence of ARI of a child in the household. The link between indoor air pollution and clinical parameters of acute respiratory illness need further investigations.

Keywords: Solid fuels; Clean fuels; Under-five children; Acute Respiratory Infection (ARI).

Introduction

Children under the age of five in underdeveloped countries around the world, acute respiratory infection (ARI) is the leading cause of death. In the present circumstances, it is one of the major causes of permanent damage and communicable disease death [1]. Acute respiratory infection is a severe infection that makes it difficult to breathe normally. Though it is nearly impossible to prove that viruses and bacteria, the main risk factors for developing an acute respiratory

illness, start in the nose, trachea (windpipe), or lungs [2]–[4]. Children, the elderly, and persons with immune system abnormalities are especially vulnerable.

On March 12, 2003, the World Health Organization (WHO) issued a global alert about a common pneumonia called severe acute respiratory syndrome [5]. According to the WHO, an estimated 2.6 million children die each year as a result of acute respiratory infections. Outpatient clinic visits by children with respiratory illnesses account for 20% to 40% of all visits, whereas hospital admissions account for 12% to 35% of all admissions [6]. In developing countries, 500 to 900 million instances of acute respiratory infection occur each year. Also, around 5 million children who are under five die of this infection annually, of which 90% occur in developing countries [7]. The precise magnitude of ARI in Bangladesh is unknown. ARI, which is already at a very large scale, is increasing at the double. Unlike cholera or acute malnutrition, there are no acceptable benchmarks for ARI, making it difficult to measure case management quality using established criteria. Several studies stated that there are high correlations between environmental risk factors, such as smoke, outdoor air pollution, indoor pollution, passive smoking, overcrowding and risk factors in the child, such as low birth weight, malnutrition, measles, breastfeeding, and vitamin 'A' deficiency, stunting, wasting, type of cooking fuel, toilet facilities, mothers literacy, medication for the intestinal parasite, place of residence, BMI, wealth index, media exposure, size of childbirth with the infections, are potential risk factors for pneumonia/ARI in developing countries [8]–[14].

The burning of cooking fuel is not necessarily the only source of indoor air pollution, although it is considered the major source. Pollutants from dirty fuel sources used for indoor space heating and lighting are among the other sources [15]. Because of the scarcity and difficulty in obtaining non-solid or clean fuels such as electricity and natural gas, low-income families in many developing countries rely on the use of low-cost but high-pollution solid fuels such as wood, coal, straws, and animal dung as their primary sources of energy for cooking and heating, yet 19.0%, 6.8%, and 50.9% of households in Bangladesh used crops, animal dung, and wood, respectively, these fuels for cooking, heating and lighting, even when access to electricity was available [16]. The fuels are primarily used in simple, inefficient, and mostly unvented family cooking stoves, resulting in enormous amounts of indoor smoke due to poor ventilation [17].

In Bangladesh, 80% of households use solid fuel for cooking (coal/lignite, charcoal, wood, straw/shrubs/grass, agricultural crops, and animal dung), while 20% use clean fuel (electricity, and liquid petroleum gas/natural gas/biogas) [18]. However, no studies have been undertaken in Bangladesh to investigate the link between ARI in children and solid fuel exposure, to the

authors' knowledge. Therefore, using the most up-to-date data available, this study looked at the link between solid fuel exposure and ARI in Bangladeshi children under the age of five.

Materials and Methods

Study area

Bangladesh is one of the most densely-populated countries in the world, with a delta of rivers that flows down in the Bay of Bengal [19]. It is low-lying, primarily riverine country in South Asia's tropical monsoon region, with a mean elevation of 85 meters above sea level and a climate marked by high temperatures, heavy rainfalls, cyclones, tidal bores, often excessive humidity, and fairly marked seasonal variations [20], [21].

Data source and Study design

For this investigation, we used data from the Bangladesh Demographic and Health Survey (BDHS) 2017-18. In the first step, 675 enumeration areas (EA) were chosen with a probability proportionate to EA size (250 in urban regions and 425 in rural areas). A systematic sample of 30 households per EA was chosen in the second step of sampling to give statistically credible estimates of key demographic and health characteristics. A total of 20,250 residential households were chosen based on this concept. About 20,100 ever-married women aged 15 to 49 were expected to complete the interviews. Mothers of 8347 children younger than 5 years were questioned about demographic, economic, pregnancy, postnatal care, immunization, and health issues, including ARI symptoms. After limiting our sample to children for whom complete data on the outcome and predictors included for the study were available, we ended up with 8321 (weighted) children for analysis. After eliminating non-eligible cases (such as other fuel types, guests, and non-surviving children) as well as observations with missing information on the child's age. Figure 1 illustrates the sampling technique. The 2017-18 BDHS report includes a detailed discussion of the sample design and technique [18].

Outcome variable

The outcome variable of interest was ARI in children under the age of five. ARI is defined in this survey as a mother's or caregiver's perception of whether their child had a cough accompanied by chest-related short, rapid breathing in the two weeks before to the survey [18]. When respondents said yes, the ARI variable was classified as 1, and when they said no, it was coded as 0.

Exposure variable

The exposure variable was solid fuel, which was determined by the type of fuel used for cooking or heating. Each household's type of cooking fuel was collected by the BDHS. 'What

type of fuel does your home primarily use for cooking?' survey respondents were asked [18]. Fuel types were classified into coal/lignite, charcoal, wood, straw/shrubs/grass, agricultural crops, animal dung, electricity, and liquid petroleum gas/natural gas/biogas. The exposure variable was a binary variable that indicates types of cooking fuel: clean fuel versus solid fuel. Coal/lignite, charcoal, wood, straw/shrubs/grass, agricultural crops, and animal dung were considered as solid fuels. The use of electricity and liquid petroleum gas/natural gas/biogas were classified as clean fuels. The fuel type variable is coded as 1 if the household uses clean fuel, otherwise 0 (solid fuel).

Covariates

By reviewing the valid literature, the most potentially related and assumed variables associated with ARI were included in this study. Household related factors (residence, region, mass media, source of drinking water, facility of toilet, wealth status, electricity, type of flooring material, type of wall material, type of roof material, and number of household member), parents/caregivers related factors (having vaccination card, mother's age, mother's education level, mother's BMI, number of living children, mother's occupation, mother's work for, household head's occupation, household head's education, and type of household head's education), and child-related factors (child's age, child's sex, order of birth, delivery place, birth weight, C-section delivery, season of birth, medication for intestinal parasites, vitamin A supplementation, and nutritional status).

In this study, participants were asked how often they listened to the radio or watched television. Those who responded at least once a week are regarded to be routinely exposed to that type of media [18]. Sources of drinking water, piped water (piped water, piped in dwellings, piped to a yard / plot, public tap / standpipe), tube well (tube well water, tube well or borehole), and other sources of drinking water, were listed (e.g., rainwater, river) , Protected or unprotected well) [22]. Some of the toilet facilities used in this study have been improved (flush toilets, flush in a piped sewer system, flush in septic tanks, flush from pit latrines, pit latrines with slabs, and ventilated pit latrines), shared (improved but shared) with other households. With), and not advanced (no flush toilet, no flush in piped sewerage system, no flush in septic tank (e.g., hanging toilet, open hole) [23]. The wealth index was reclassified into upper economic class (upper 20% asset value), middle economic class (middle 40% asset value) and lower economic class (lower 40% asset value) [24]. The survivor also observed the main material of the floor/roof/wall of the dwelling. The floor/roof/wall was classified as natural (earth/sand and dung), rudimentary (wood planks and palm/bamboo), and finished (vinyl or asphalt strips, ceramic tiles, cement, and carpet) [18].

The BDHS obtained vaccination coverage data in two methods in 2017-18: from immunization cards provided to interviewers and from mothers' verbal remarks. The interviewers transcribed the vaccination dates straight into the questionnaire if the cards were available. The respondent was asked to recollect the immunizations administered to her child if there was no vaccination card for the child if the vaccination card was unavailable for the child or if a vaccine had not been noted as being given on the vaccination card [18]. Mother's/household head's occupation categorized as agricultural/skilled worker (farming/agricultural work and semi-skilled labor/service), household/unskilled worker (unskilled labor, home-based manufacturing, domestic service, and other), industrial worker (Professional/technical, business, factory work or blue-collar service, poultry or cattle raising).

In this study, weight at birth was classified as low if the weight of the child was less than 2500 grams and normal if greater than 2500 grams. Two anthropometric indices, height-for-age and weight-for-height z-scores, were used to assess a child's nutritional status, as suggested by the WHO [25]. The z-score indicates how far a given result deviates from the mean, and it is commonly used to normalize data. The z-score was used in this study to compare stunting and wasting in children under the age of five by gender and age group. If a child's weight-for-height z-score was less than -2, they were called wasted, and if their height-for-age z-score was less than -2, they were considered stunted.

Statistical analyses

To illustrate the distribution of variables, descriptive statistics were utilized. In this study, numbers and percentages were used for categorical variables. We used Chi-square tests to identify factors associated with ARI in the children and P-value <0.05 was taken as statistically significant. We fitted the design-based binary logistic regression [26] to assess the association between child ARI and types of cooking fuel in a household. For the adjusted association, the model was adjusted for type of cooking fuel, type of roof material, child's age (months), and sex of the child. The crude odds ratio (COR) and adjusted odds ratio (AOR) were calculated, along with the 95% confidence interval (CI) and p-values. The specified predictor variables were used in multiple logistic regression. Survey package in R was used to conduct the statistical analyses and data management for this study.

Variable selection

The variables were chosen in two steps. In the first stage, the Rao and Scott Chi-squared test (a design-adjusted variation of the Pearson Chi-squared test) [27] was employed to account for the data's cluster-design effect. In total, 21 variables were significant with ARI at p-value less than 0.200 (Table 1, 2, and 3). Bivariate logistic regression was carried out independently for

each of the selected factors in the second stage, and 16 variables were determined to be significant at the 5% significance level. The final model (full multivariable model) was then created using a manual stepwise backward elimination approach. The least significant variable was eliminated at each phase of the stepwise elimination process, and this process was repeated until all of the variables in the model were significant at the 5% significance level. In this stage, 4 variables were found to be significant at the 5% significance level.

With a cut-off value of 4.00, we used the variance inflation factor (VIF) value to analyze multicollinearity in the final model (Table 4). The area under the curve (AUC) of the receiver operating characteristic curve was used to verify the prediction accuracy of the final model (Table 5). We also utilized the Hosmer and Lemeshow goodness-of-fit test to get a sense of the final model's overall fit (Table 5).

Results

Study sample characteristics

The study team approached 20250 houses, and 20160 households were eligible for interview. Floodwater totally undermined three clusters, resulting in the loss of 90 households. As such, 20160 households with 8347 children were enrolled in the study from those 26 children eliminated due to visitors and non-surviving children. Finally, 8321 observations were obtained for conducting this study (Figure 1).

Socio-demographic characteristics

Table 1 contains the results of chi-square analysis for identifying household factors associated with ARI. The results of the chi-square analysis indicated that types of the region of the country, media accessibility, toilet facility, types of cooking fuel, wealth index, electricity accessibility, types of roof material, types of wall material are significant factors as the p-value is less than 0.05. Among 8321 children, 25.38% were from Dhaka, 51.76% of the household had media accessibility, 70.52% had unimproved toilet facilities, 41.77% were from the poorest households, 78.97% used solid cooking fuel, and 82.32% had electric accessibility.

Most of the mothers (79.68%) of the children are from the 15-24 years' age group, and a large group of mothers was vaccinated. As for parents' characteristics, 48.64% of respondents were primarily completed, 77.89% of household heads were industrial workers, and 49.29% of household heads had no education (Table 2).

In total, 58.47% of children were included from the 24-59 age group. There were 52.16% of male children, and 30.72% were a stunt. The birth order distribution of children was 87.5% in

the 1-3 group, 59.3% born at a health facility, 69.95% delivered at a normal weight, and 66.61% children were delivered by normal delivery (Table 3).

Use of biomass fuel at household level

In total, 78.97% of households used solid fuel: 43.8% used wood, 0.6% used straw, 27.9% used crops, and 0.1% used cow dung (Figure 2). Rangpur and Barisal regions of Bangladesh had the highest prevalence of solid fuel, whereas the lowest prevalence was seen in Dhaka (Figure 3). The prevalence of ARI is significantly associated ($P<0.05$) with the type of fuel used in the home, according to the results of the Rao-Scott Chi-squared independence test (Table 1).

Model evaluation

The VIF result demonstrated no multicollinearity in the final multivariable logistic model (Table 4). The classification accuracy is acceptable, with an AUC value of 0.61. The model also passed the Hosmer and Lemeshow goodness-of-fit test (value = 8.2419, degrees of freedom = 8, P-value = 0.760), indicating that there was no lack of fit (Table 5).

Association between the prevalence of ARI and solid fuel

Table 6 shows the crude and adjusted association between household fuel use and ARI among under 5 years' children in Bangladesh. In crude analysis, the solid fuel risk group in household fuel type was associated with 1.693 times higher odds of ARI than the clean fuel risk group (COR: 1.693; 95% CI: 1.058–2.709). After adjusting the model for potential confounders and risk factors, we observed 1.692 times the odds of ARI among those children from the solid fuel risk group in households than those from clean fuel (AOR: 1.692; 95% CI: 1.053–2.718).

Discussion

Of the study households, solid fuel (coal/lignite, charcoal, wood, straw/shrubs/grass, agricultural crops, and animal dung) was the most widely used fuel for cooking in Bangladesh. These findings show an association between the usage of solid fuel in the household and ARI episodes in children under five years old. The prevalence of ARI was greater in children who lived in a household that used solid fuel. A recent national representative sample of a Bangladesh Urban Health Survey conducted in 2013 reported 39.5% of solid fuel users in urban areas while 60.5% are clean fuel users [28]. More than half of households in India and Nepal used solid fuel for cooking: 54% in India (2015-2016) and 66% in Nepal (2016). In 2016, Indonesia had the lowest amount of household air pollution, with 23% [29].

In our study, we found that ARI is more frequent in case of the children of the uneducated mother.

According to a study conducted by Johns Hopkins University's Department of International Health, most mothers believed that a "wind-carrying sickness" may kill their kid, but ARI is deemed to be more controllable, and this is due to illiteracy [30]. Government's effort to educate girls beyond a secondary level is therefore called for. In this instance, the government's free primary and secondary education program is extremely important, and it should be strengthened and expanded [31]. This is likely due to the fact that moms who use vaccination programs are more aware of health-care facilities and are more likely to seek early consultation for their children's illnesses, perhaps avoiding serious disease [32].

Our findings show that women in older age cohorts, as compared to those in the 15-24 age group, and those with higher birth order, as compared to the first, have a lower risk of ARI. This can be due to older women's collected childcare expertise and experience, which unmistakably gives them an advantage over younger women [31]. Household wealth was defined according to the respondent's reported household assets, was assigned a standardized score, and was categorized into three categories, namely, lower, middle, and higher. Being overweight (BMI 25 kg/m2) is a growing problem that has been associated with a risk for acute respiratory infections [33].

In our study, the incidence of ARI was higher in stunted infants, wasted infants, and infants that have low birth weight. Stunting is linked to a long period of time spent in poor environmental circumstances and having a low socioeconomic level as a child [34]. ARI bouts that are more frequent and last longer may cause growth retardation. Moreover, other nutritional disorders are also associated with ARI. Malnutrition was found to be strongly related with ARI in this investigation, as it has been in prior studies [15]. A study in the Philippines included age stratified risks in children less than 23 months of age and reported the highest risk of death from ARI due to malnutrition among those aged 12-22 months [14]. A study in New Delhi revealed severe malnutrition as the predictor of mortality in ARI in 2 weeks to 5 years old children. Overall, malnutrition has been associated with a two- to three-fold increase in ARI mortality [35].

Although the studies differ in terms of design, exposure measurement, and outcome evaluation, the current findings concerning the relationship between solid fuel consumption and ARI incidence are similar to most studies from India (OR 4.0, 95% CI 2.0e7.9), Nepal (OR 2.3, 95% CI 1.8-2.9) Zimbabwe (OR 2.1, 95% CI 1.5-3.1), Gambia (OR 5.2, 95% CI 1.7-15.9), and a meta-analysis of these studies (OR 2.3, 95% CI 1.9-2.7) [8]–[14]. Investing in safe fuel and adapting to it with necessitating significant behavioral changes and other factors must be considered as part of broader initiatives, such as reforming kitchen structure, upgrading

knowledge, as well as boosting adequate and satisfactory level of awareness among household members and broader communities, which can facilitate lowering the risk of air pollution and concomitant childhood ARI prevalence.

Strengths and limitations

To the best of our knowledge, this is the first study to assess the association between exposure to solid fuel and ARI episodes among children aged under 5 years in Bangladesh. We used a sufficiently large nationally representative dataset that reflects Bangladesh's whole population. We also considered a wide range of factors that influence the public's knowledge of the issue. We also looked at model-fitting criteria, which were mostly absent in the literature. Despite this, there were certain limits to our research. Because we used secondary data, we had no control over the variable selection, data quality, or measurement indication. In this study, environmental and behavioral factors were missing, which is important in exposure assessment. Furthermore, the study was performed three years ago; in that period, the level of fuel used among households may have shifted.

Conclusion

The current study yields solid evidence that solid fuel significantly augments children's risk of ARI in Bangladesh. Despite the limitations talked over in the above discussions, the strength of the association and the frequency of reporting of fuel type as the main reason for ARI are remarkable enough to warrant the conclusion that solid fuel is a main driver of ARI in Bangladesh. This finding underscores the demand of bettering the cooking fuel in order to reduce ARI disease in many parts of the country. Our study also suggests that ARI, which is already at a very large scale, is increasing at double. Government should invest greater resources in ARI prevention and control and explicitly consider ARI as a top priority phase and scenario.

Conflict of interest

No conflict of interest

Author`s contribution

Mohammad Nayeem Hasan: Conceptualization, Supervision, Methodology, Formal Analysis, Writing- Original draft, Reviewing and Editing. Tanvir Ahammed: Methodology, Formal Analysis, Writing- Reviewing and Editing. Aniqua Anjum: Methodology, Writing-Reviewing and Editing. Sabrin Sultana: Writing-Reviewing and Editing. M. Noor-E-Alam

Siddiqui: Methodology, Writing-Reviewing and Data curation. Sohan Sarwar: Methodology, Writing-Reviewing and Data curation.

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Tables and figures

Table 1 Frequency distribution of households (weighted*) on use of solid fuel and acute respiratory infection (ARI) among children younger than 5 years in Bangladesh.

Factors	ARI			
	Yes, N (%)	No, N (%)	Total, N (%)	P-value
Total	**250 (3.00)**	**8071 (97.00)**	**8321 (100.00)**	
Place of residence				
Urban	57 (2.56)	2186 (97.44)	2243 (26.96)	0.188
Rural	192 (3.17)	5885 (96.83)	6078 (73.04)	
Region of the country				
Barisal	19 (4.16)	443 (95.84)	462 (5.55)	<0.001
Chittagong	48 (2.76)	1698 (97.24)	1746 (20.99)	
Dhaka	42 (1.97)	2070 (98.03)	2111 (25.38)	
Khulna	13 (1.74)	754 (98.26)	768 (9.23)	
Mymensingh	17 (2.38)	688 (97.62)	705 (8.48)	
Rajshahi	38 (3.94)	933 (96.06)	971 (11.67)	
Rangpur	53 (5.98)	826 (94.02)	879 (10.56)	
Sylhet	20 (2.95)	658 (97.05)	679 (8.15)	
Media accessibility				
Yes	139 (3.65)	3661 (96.35)	3800 (51.76)	0.002
No	80 (2.26)	3461 (97.74)	3541 (48.24)	
Source of drinking water				
Piped water	5 (1.12)	481 (98.88)	486 (6.63)	0.089

Tube well	206 (3.11)	6423 (96.89)	6629 (90.30)	
Other	7 (3.13)	219 (96.87)	226 (3.07)	
Toilet facility				
Improved	43 (2.01)	2121 (97.99)	2164 (29.48)	0.002
Unimproved	175 (3.39)	5001 (96.61)	5177 (70.52)	
Type of cooking fuel				
Clean fuel	30 (1.95)	1512 (98.05)	1542 (21.03)	0.027
Solid fuel	189 (3.25)	5603 (96.75)	5792 (78.97)	
Wealth index				
Higher	74 (2.27)	3201 (97.73)	3276 (39.36)	0.001
Middle	40 (2.56)	1529 (97.44)	1569 (18.86)	
Lower	135 (3.89)	3341 (96.11)	3476 (41.77)	
Electricity accessibility				
No	56 (4.11)	1315 (95.89)	1371 (18.68)	0.023
Yes	162 (2.72)	5808 (97.28)	5970 (81.32)	
Type of flooring material				
Natural	155 (3.35)	4472 (96.65)	4672 (63.02)	0.091
Rudimentary	2 (2.80)	68 (97.20)	68 (0.96)	
Finished	62 (2.33)	2582 (97.67)	2582 (36.02)	
Type of roof material				
Natural	1 (2.69)	50 (97.31)	51 (0.69)	0.008
Rudimentary	1 (27.26)	2 (72.74)	3 (0.04)	
Finished	217 (2.97)	7071 (97.03)	7287 (99.27)	
Type of wall material				
Natural	24 (3.88)	605 (96.12)	629 (8.57)	0.042
Rudimentary	17 (5.48)	298 (94.52)	315 (4.29)	
Finished	177 (2.77)	6220 (97.23)	6397 (87.13)	
Number of household member				
Below median	80 (2.94)	2653 (97.06)	2733 (32.85)	0.855
Above median	169 (3.03)	5418 (96.97)	5588 (67.15)	

*Frequencies are weighted using sample weight

Table 2 Frequency distribution of parents (weighted*) on use of solid fuel and acute respiratory infection (ARI) among children younger than 5 years in Bangladesh

Factors	ARI			
	Yes, N (%)	No, N (%)	Total, N (%)	P-value
Total	**250 (3.00)**	**8071 (97.00)**	**8321 (100.00)**	
Mothers age group (in years)				
15-24	126 (3.19)	3824 (96.81)	3950 (47.47)	0.722
25-34	105 (2.81)	3613 (97.19)	3718 (44.68)	
45+	19 (2.97)	634 (97.03)	654 (7.86)	
Vaccination				
Yes	43 (3.33)	1252 (96.67)	1295 (79.68)	0.014
No	3 (0.77)	328 (99.23)	330 (20.32)	
Mother's education level				
Secondary or Higher	29 (2.18)	1287 (97.82)	1316 (15.81)	0.221
Primary	127 (3.14)	3920 (96.86)	4047 (48.64)	
No Education	94 (3.18)	2864 (96.82)	2958 (35.55)	
Mother's BMI				
Obese	10 (2.07)	477 (97.93)	487 (5.96)	0.719
Overweight	54 (3.20)	1624 (96.80)	1678 (20.53)	
Normal Weight	150 (3.07)	4734 (96.93)	4734 (59.73)	
Under Weight	34 (3.04)	1093 (96.96)	1093 (13.79)	
Number of living children				
<=2	178 (3.00)	5751 (97.00)	5929 (71.26)	0.990
3-4	62 (3.03)	1994 (96.97)	2056 (24.71)	
5+	10 (2.88)	326 (97.12)	336 (4.03)	
Mother's occupation				
Agriculture	87 (3.64)	2314 (96.36)	2401 (28.86)	0.026
Don't work	121 (2.52)	4670 (97.42)	4791 (57.59)	
Industires	42 (3.72)	1085 (96.28)	1127 (13.55)	
Mother's work for				
Family	88 (4.05)	2077 (94.95)	2165 (61.43)	0.111
Else	15 (2.23)	641 (97.77)	655 (18.59)	

Self	27 (3.83)	677 (96.17)	704 (19.98)	
Household head's occupation				
Agriculture	62 (3.73)	1590 (96.27)	1651 (19.89)	0.185
Don't work	4 (1.95)	181 (98.05)	184 (2.22)	
Industries	185 (2.86)	6283 (97.14)	6468 (77.89)	
Household head's education				
Secondary or Higher	25 (1.70)	1436 (98.30)	1461 (17.87)	0.017
Primary	85 (3.15)	2600 (96.85)	2685 (32.84)	
No Education	137 (3.40)	3892 (96.60)	4029 (49.29)	
Type of household head's education				
School	216 (3.10)	6766 (96.90)	6982 (90.36)	0.969
Madrasha	23 (3.13)	721 (96.87)	745 (9.64)	

*Frequencies are weighted using sample weight

Table 3 Frequency distribution of children (weighted*) on use of solid fuel and acute respiratory infection (ARI) among children younger than 5 years in Bangladesh

Factors	ARI			
	Yes, N (%)	No, N (%)	Total, N (%)	P-value
Total	**250 (3.00)**	**8071 (97.00)**	**8321 (100.00)**	
child's age (months)				
24-59	112 (2.29)	4753 (97.71)	4865 (58.47)	<0.001
12-23	69 (4.09)	1611 (95.91)	1680 (20.19)	
0-11	70 (3.92)	1706 (96.08)	1776 (21.34)	
Sex of Child				
Male	155 (3.58)	4185 (96.42)	4340 (52.16)	0.003
Female	95 (2.38)	3886 (97.62)	3981 (47.84)	
Birth Order				
1-3	210 (2.88)	7074 (97.12)	7284 (87.54)	0.074
4-6	39 (4.04)	935 (95.96)	935 (11.71)	
6+	1 (0.98)	62 (99.02)	62 (0.75)	
Place of delivery				

Home	93 (3.62)	2468 (96.38)	2561 (50.09)	0.337
Hospital	79 (3.09)	2472 (96.51)	2551 (59.91)	
Weight at birth				
Low birth weight	21 (3.03)	677 (96.97)	698 (30.05)	0.762
Normal birth weight	53 (3.29)	1572 (96.71)	1625 (69.95)	
Delivery by C-section				
Yes	49 (2.86)	1656 (97.14)	1705 (33.39)	0.208
No	123 (3.61)	3278 (96.39)	3401 (66.61)	
Season of birth				
Summer	73 (3.40)	2077 (96.60)	2150 (25.84)	0.051
Autumn	46 (2.46)	1829 (97.54)	1875 (22.53)	
Winter	75 (3.70)	1942 (96.30)	2016 (24.23)	
Spring	56 (2.45)	2224 (97.55)	2279 (27.39)	
Medication for intestinal parasites				
No	168 (3.41)	4759 (96.59)	4927 (59.24)	0.145
Yes	82 (2.41)	3301 (97.59)	3382 (40.71)	
Vitamin A supplementation				
No	66 (2.96)	2170 (97.04)	2236 (26.95)	0.883
Yes	184 (3.03)	5879 (96.97)	6063 (73.05)	
Stunting				
No	159 (2.94)	5258 (97.06)	5417 (69.28)	0.217
Yes	85 (3.54)	2316 (96.46)	2402 (30.72)	
Wasting				
No	221 (3.09)	6924 (96.91)	7145 (91.56)	0.496
Yes	24 (3.60)	635 (96.40)	659 (8.44)	

*Frequencies are weighted using sample weight

Table 4 Generalized variance inflation (GVIF) value of the final model of ARI among under 5 years children in Bangladesh

Variables	Degrees of freedom	GVIF
Type of cooking fuel	1	1.01

Type of roof material	2	1.02
child's age (months)	2	1.02
Sex of Child	1	1.02

Table 5 Test for goodness of fit and predictive accuracy of the final model

Hosmer and Lemeshow goodness of fit test		
Value	df	P-value
8.2419	8	.760
Area under the curve (AUC) of the receiver operating characteristic curve (ROC)		
Value	0.61	

Table 6 Association between household type of fuel use and ARI among under 5 years children in Bangladesh

		Unadjusted model			Adjusted model[1]		
Variables		COR	95% CI	P-value	AOR	95% CI	P-value
Type of cooking fuel	Solid fuel	1.693	[1.058, 2.709]	0.028	1.692	[1.053, 2.718]	0.030
	Clean fuel	1			Ref.		

COR crude odds ratio, AOR adjusted odds ratio, CI confdence interval, Ref. reference

[1]The adjusted analysis using the design-based binary logistic regression, adjusted for type of cooking fuel, Type of roof material, child's age (months), and sex of child.

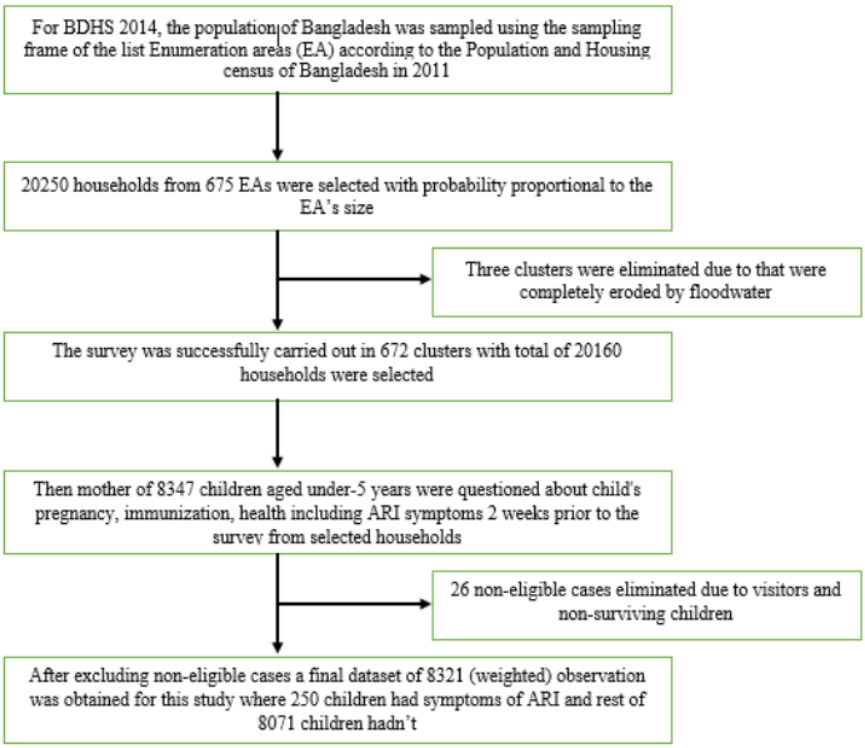

Figure 1 Sample procedure of 2017 BDHS and selection of sample for the study

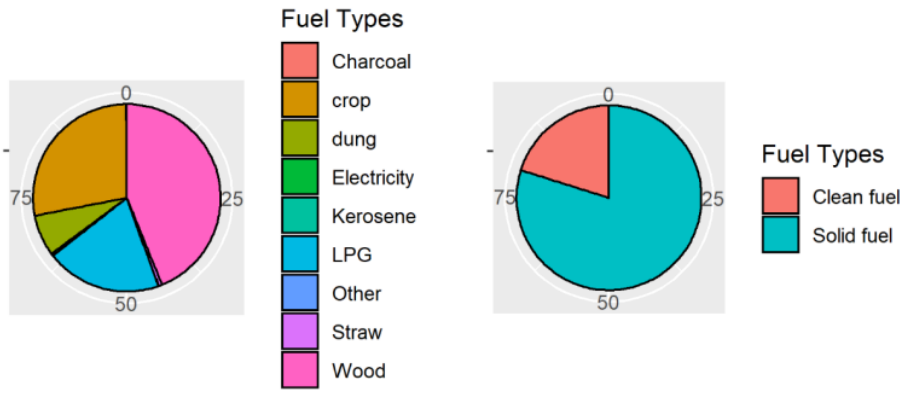

Figure 2 Fuel types used in study area. LPG, liquefied petroleum gas

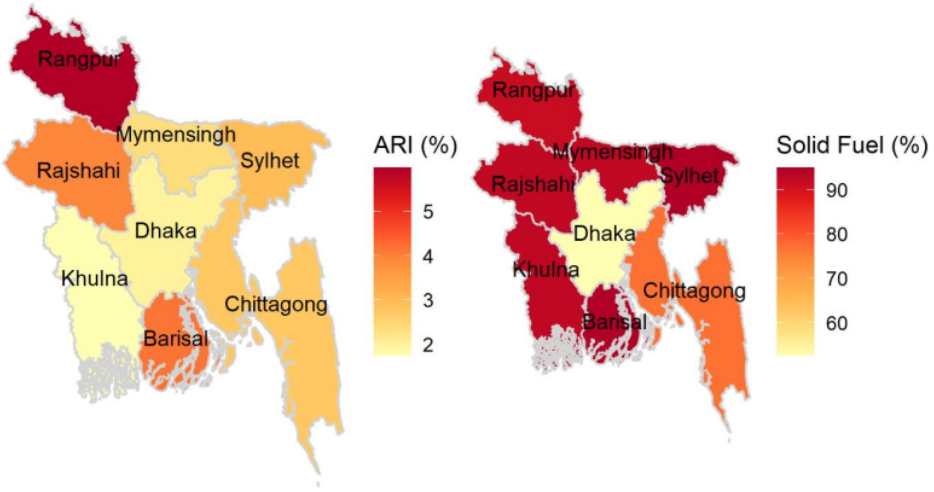

Figure 3 Prevalence of acute respiratory infection (ARI) in different regions of Bangladesh

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