**Association between the type of fuel use with acute respiratory infections among children under-five in Bangladesh**

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**Abstract:**

Low-income families often depend on fuels such as wood, coal, and animal dung for cooking. It is not clear whether the use of other fuel has health advantage over biomass fuels. Acute respiratory infections (ARI) is a leading cause of mortality in under five children in Bangladesh. Therefore, we aim to conduct a study to detect the effects of fuel usage on ARI in children. Using the Bangladesh Demographic & Health Survey (BDHS) 2014 data, we estimated the effect of fuel use on ARI by constructing logistic regression models. A multiple logistic regression model was used to assess risk factors of ARI due to fuel use. From the analysis, we found the crude (only type of fuel in the model) odds ratios (COR) for the ARI were 1.63 (95% confidence interval (CI): 1.16-2.36). That means children in households using biomass fuels had 1.63 times higher odds of experiencing ARI than children from households using fossil fuels. After adjusting for child’s sex, age and place of residence; mother’s education, and household wealth index, indicated that the effect of biomass fuels is also more acute as adjusted odds ratio (AOR) for the ARI were 1.56 (CI: 1.09-2.57) compared with the effect of fossil fuel. Children belonging to age group 0-11 months had 1.33 times higher odds to having ARI (AOR = 1.33; 95% CI: 1.28-2.93) as compared to children belonging to 24-59 age groups. Mother’s education level is another major factor in this field. There is an association between fuel usage and ARI in children. This study also identified various socio-demographic, nutritional and environmental risk factors for ARI which can be tackled by effective education of the community and appropriate initiatives taken by the government.

**Keywords:** Acute Respiratory Infection; Cooking fuels; Under-five children; Biomass fuels; Logistic regression.

**Introduction:**

Acute respiratory infections (ARI) is a leading cause of mortality in under five children in developing countries throughout the world. Nowadays it is one of the major causes of permanent damage and communicable disease death [1]. Acute respiratory infection is an intense infection that prevents normal breathing function. Though it is almost inconceivable to validate viruses and bacteria, the main risk factors that increase the likelihood of developing acute respiratory infection, it generally begins in the nose, trachea (windpipe), or lungs [2]. The common viruses that are responsible for ARI are influenza viruses (IFVs), respiratory syncytial virus (RSV), parainfluenza viruses (PIVs) [3]–[5]. It is particularly dangerous for children, older adults, and people with immune system disorders. The serious rise in illness and mortality caused by respiratory viruses have made ARI a top priority in the global health challenge [6]. The precise magnitude of ARI in Bangladesh is unknown. ARI, which is already at a very large scale, is increasing at the double. The risk of infectious disease epidemics is usually considered to be low, but this may lead to avoid the common conditions such as ARI which is less noticeable than epidemic-prone diseases in Bangladesh [7]. There are no acceptable targets for ARI, unlike for cholera or severe malnutrition, making it difficult to monitor the quality of case management on the basis of accepted standards.

The international consultation on control of ARI, 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, breast feeding and vitamin ‘A’ deficiency, stunting, wasting, type of cooking fuel, toilet facilities, mothers literacy, medication for intestinal parasite ,place of residence, BMI, wealth index ,media, size of child birth with the infections [8].

The burning of cooking fuel is not necessarily the only source of indoor air pollution, although it is considered the major source. Other sources include pollutants generated from unclean fuel sources used for indoor space heating and lighting [9]. For instance, low-income families often depend on the use of low-cost but high-pollution biofuels such as wood, coal, straws, and animal dung as the primary source of energy for cooking and heating in many developing countries due to limited availability and access to non-solid fuels such as electricity and natural gas , yet 19.0%, 6.8%, and 50.9% of households in Bangladesh used crop, animal dung and wood, respectively, these fuels for cooking, heating and lighting, even when access to electricity was available [10]. The fuels are typically burned in simple, inefficient and mostly unvented household cooking stoves, which, combined with poor ventilation, generate large volumes of smoke indoors [11]. Exposure to these pollutants in developing countries is reported to be higher in women and children [12].

There is limited evidence that link fuel use with ARI among under-five children in Bangladesh. The aim of this study was to assess the association of fuel type and ARI among children under-five and other risk factors with the prevalence of suffering from acute respiratory infection (ARI) among under-five children in Bangladesh.

**Ethics approval**

Our study was wholly based on an analysis of existing public domain health survey datasets obtained from BDHS 2014, which is freely available online with all identifier information removed. Informed consent was obtained from participants while interviewing them. The BDHS 2014 was reviewed and approved by the ICF Macro Institutional Review Board and the National Research Ethics Committee of the Bangladesh Medical Research Council. This survey was conducted by the National Institute of Population Research and Training (NIPORT) of the Ministry of Health and Family Welfare and implemented by Mitra and Associates, Bangladesh.

**Method:**

**Data source and Study design**

We used latest available Bangladesh Demographic and Health Survey (BDHS) 2014 data for our study. 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.

**Outcome variable**

In this study, the output or response variable was Acute Respiratory Infection (ARI). If a child had a cough accompanied by chest related short, rapid breathing in the 2 weeks before the survey was defined as suffering from ARI. We considered the outcome variable by categorized (Yes/No) all the children under-five.

**Exposure variable**

The exposure variable was a binary variable that indicates types of cooking fuel: fossil fuel versus biomass fuel. The source of cooking fuel also has effect on ARI. BDHS collected the information of type of cooking fuel from each households [13]. Fuel type variable is coded as 1 if the household use fossil fuel, otherwise 0 (biomass fuel).

**Potential confounding variables**

By reviewing the valid literature, the most potentially associated variables included in adjusted model: child-related (age, sex, vaccination, stunting, wasting, medication for intestinal parasites, size at birth, place of delivery and BMI); maternal factors (formal education, type of delivery, presence of pregnancy complications,); and household (wealth index ,access to safe water, types of cooking fuel, residential area, sanitation).

**Sampling**

BDHS sample is stratified and selected into two stages. In the first stage, 600 EAs are selected with probability proportional to the EA’s size with 207 EAs in the urban areas and 393 EAs in rural areas. Then in the second stage of sampling a systemic sample selection of 17989 households (6210 in urban and 11779 in rural) on an average of 30 households per EA were made using systematic sampling. Due to the non-proportional allocation of sample to divisions and urban and rural areas, and the differences in response rates in sample, sampling weights were adjusted to ensure the representativeness of the survey results at national level. Adjustment for clustering in the sample removes underestimation of variability in the estimates by weighting the data for under sampling and oversampling within strata. A detailed description of the weighting procedure can be found in the BDHS report [13].

**Statistical analyses**

Descriptive statistics of each of the selected confounding variables and distribution of ARI by different variables were shown by adjusting sampling weight. Chi square test was used to identify factors association with ARI in the children. ‘P’ value <0.05 was taken as significant and ‘P’ value <0.001 was taken as highly significant. A multiple logistic regression was carried out with the selected predictor variables. Variables with a *p-*value > 0.05 were excluded from the model. Using these models, we reviewed the variability of the results from the models. In the crude model, only the ARI and fuel type was used. For the adjusted model, other confounding variables with ARI were considered. All statistical analyses were performed by R. The final adjusted model included the independent variables: child age (in months), stunting, wasting, types of cooking fuel, toilet facilities, mother’s education level, medication for intestinal parasites, sex of a child, place of residence, mother’s age group, body mass index, size of child at birth. Statistical analysis was performed using the R software.

**Results**

The results of chi-square analysis for identifying factors associate with ARI were shown in Table 1. The results of the chi-square analysis indicated that types of the cooking fuel, age of the children, stunted infants, wasted infants, mothers education level, sex of the child, mother’s age and mother’s BMI are significant factors as p-value is less than 0.05. From this table, it can be said that burning of biomass fuel (83.8%), wasted infants (14.4%), residence in the rural area (74.1%), are mostly responsible for frequent ARI in children.

Table 1. Chi-square test for identifying factors associate with ARI

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Factors | ARI | | |  |
| Yes, N (%) | No, N (%) | Total, N (%) | P-value |
| **Type of cooking fuel** | | | | |
| Fossil fuel | 44 (11.70) | 1096 (16.5) | 1140 (16.20) | 0.039 |
| Biomass fuel | 332 (88.30) | 5546 (83.5) | 5878 (83.80) |  |
| **Child age(months)** | | | | |
| 0-11 | 104 (27.66) | 1184 (17.78) | 1287 (18.30) | <0.001 |
| 12-23 | 97 (25.80) | 1381 (20.74) | 1478 (21.02) |  |
| 24-59 | 175 (46.54) | 4093 (61.48) | 4268 (60.68) |  |
| **Stunting** | | | | |
| Yes | 155 (43.5) | 2236 (36.0) | 2391 (36.4) | 0.028 |
| No | 201 (56.5) | 3975 (64.0) | 4176 (63.6) |  |
| **Wasting** | | | | |
| Yes | 63(17.7) | 882(14.2) | 945(14.4) | 0.012 |
| No | 293 (82.3) | 5328 (85.8) | 5621 (85.6) |  |
| **Mothers education level** |  |  |  |  |
| Secondary or Higher | 179 (47.7) | 3674 (55.2) | 3853 (54.8) | <0.001 |
| Primary | 143 (38.1) | 1821 (22.4) | 1964 (27.9) |  |
| No Education | 52 (13.9) | 1162 (17.5) | 1214 (17.3) |  |
| **Sex of Child** |  |  |  |  |
| Male | 222 (59.2) | 3461 (52.0) | 3683 (52.4) | 0.037 |
| Female | 153 (40.8) | 3196 (48.0) | 3349 (47.6) |  |
| **Mothers age group (in years)** |  |  |  |  |
| 15-24 | 203 (54.1) | 3092 (46.5) | 3296 (46.9) | 0.027 |
| 25-34 | 142(37.9) | 3019(45.3) | 3161(45.0) |  |
| 35-44 | 28(7.6) | 510(7.7) | 538(7.7) |  |
| 45+ | 1(0.3) | 36(0.5) | 37(0.5) |  |
| **Wealth index** |  |  |  |  |
| Higher | 42 (11.2) | 1324 (19.9) | 1366 (19.4) | 0.492 |
| Middle | 140 (37.3) | 2587 (38.9) | 2728 (38.8) |  |
| Lower | 193 (51.5) | 2745 (41.2) | 2938 (41.8) |  |
| **Place of residence** |  |  |  |  |
| Urban | 77(20.5) | 1745 (26.2) | 1823 (25.9) | 0.045 |
| Rural | 298 (79.5) | 4911 (73.8) | 5210 (74.1) |  |
| **Body mass index (mother)** |  |  |  |  |
| Obese | 14 (3.8) | 250 (3.8) | 264 (3.8) | 0.018 |
| Overweight | 39 (10.3) | 1026 (15.5) | 1065 (15.3) |  |
| Normal Weight | 214 (57.3) | 3919 (59.4) | 4133 (59.2) |  |
| Under Weight | 107 (28.6) | 1408 (21.3) | 1515 (21.7) |  |

Table 2 present odds ratios and 95% confidence intervals (CI) for ARI among children aged under-five. The logistic regression analysis shows that children belongs to family who used biomass fuel were significantly higher odds to effected by ARI (OR 1.63; 95% CI 1.16–2.36) compared to fossil fuel users. The effect remained significant (adjusted odds ratio (AOR) = 1.56; 95% CI 1.09–2.57) after adjusting for demographic and socioeconomic variables that were significant in chi-square test (Table 3).

Table 2. Odds ratio of the adjusted multiple logistic regression model

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Variables |  | Crude OR | 95% CI | P-value |
| **Type of cooking fuel** | Biomass fuel | 1.63 | [1.16, 2.36] | 0.007 |
|  | Fossil fuel | 1 |  |  |

The odds ratio, 95% confidence interval of the adjusted multiple logistic regression model (Having ARI due to use biomass fuel vs. haven’t ARI and fuel user) were shown in Table 3. As the age of child increased, they were more likely to have ARI due to use biomass fuel, children age between 0-11 months was 1.33 times (CI: 1.28-1.93) higher odds of having ARI as compared with children age between 24-59 months. Children from mothers having a primary education was 1.54 times (AOR = 1.54; 95% CI: 1.12-2.12) higher odds of experiencing ARI as compared with the children from mothers with secondary education. Children who identify as belonging to the rural area were more likely to having ARI due to use biomass fuel (AOR = 1.07, 95% CI 0.76–1.53). Wasting and place of residence were not associated with ARI due to fuel use.

Table 3. Odds ratio of the adjusted multiple logistic regression model

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Variables |  | AOR | 95% CI | P-value |
| Type of cooking fuel |  |  |  |  |
|  | Biomass fuel | 1.56 | [1.09, 2.57] | 0.041 |
|  | Fossil fuel | Ref. |  |  |
| Child age (in months) |  |  |  |  |
|  | 0-11 | 1.33 | [1.28, 1.93] | <0.001 |
|  | 12-23 | 0.939 | [0.66, 1.33] | 0.724 |
|  | 24-59 | Ref. |  |  |
| Stunting |  |  |  |  |
|  | Yes | 1.35 | [1.05, 1.82] | 0.034 |
|  | No | Ref. |  |  |
| Wasting |  |  |  |  |
|  | Yes | 1.18 | [0.83, 1.66] | 0.344 |
|  | No | Ref. |  |  |
| Mothers education level |  |  |  |  |
|  | No education | 1.19 | [0.77, 1.83] | 0.425 |
|  | Primary | 1.54 | [1.12, 2.12] | 0.007 |
|  | Above secondary | Ref. |  |  |
| Sex of Child |  |  |  |  |
|  | Female | 0.75 | [0.57, 0.98] | 0.037 |
|  | Male | Ref. |  |  |
| Place of residence |  |  |  |  |
|  | Rural | 1.07 | [0.76, 1.53] | 0.691 |
|  | Urban | Ref. |  |  |
| Mothers age group (in years) |  |  |  |  |
|  | 45+ | 1.26 | [0.69, 2.02] | 0.976 |
|  | 35-44 | 1.02 | [0.56, 1.76] | 0.950 |
|  | 25-34 | 0.89 | [0.66, 1.20] | 0.446 |
|  | 15-24 | Ref. |  |  |
| BMI (mother) |  |  |  |  |
|  | Under weight | 0.670 | [0.326, 1.527] | 0.305 |
|  | Normal weight | 0.546 | [0.275, 1.212] | 0.106 |
|  | Overweight | 0.485 | [0.221, 1.151] | 0.082 |
|  | Obese | Ref. |  |  |

**Discussion:**

Of the study households, biomass fuel was the most widely used fuel for cooking in Bangladesh. This study shows strong associations with increased between biomass fuel and prevalence of ARI in children. Children living in households that are reliant on biomass fuels are about three times more likely to suffer from an ARI compared to children living in homes reliant on clean fuels. This implies that the children exposure response for biomass fuel smoke is the most toxic among all the fuel types. This result similar with most studies conducted in Bangladesh. A study conducted with Bangladesh Urban Health Survey data in 2013 showed that children in households biomass fuel for cooking were more likely to suffer from respiratory disease compared to children from households using fossil fuel [14].

In our study, we found that ARI is more frequent in the children of uneducated mother. A study by the Department of International Health, Johns Hopkins University [15] found that most mothers believed that a ‘wind-carrying disease can kill their child whereas ARI is considered to be more manageable and this is the result of illiteracy. Government effort to educate girls beyond secondary level is therefore called for. The government’s free primary and secondary educational program is very relevant in this case and hence should be strengthened and be propelled to higher levels [16]. This is probably because mothers utilizing immunization services are better aware of health care facilities and probably seek early consultation for illness of their children, which probably avoids severe illness [17]. Our result indicates that women from higher age cohorts, compared to those in the 15-24 age cohort, and those with a higher birth order, compared to the first, reduce the probability of occurrence of ARI. This can be attributed to the knowledge and experience concerning childcare accumulated by older women over time which unambiguously gives them an edge over younger women [16].Household wealth was defined according to the respondents reported household assets and was assigned a standardized score and was categorized into three categories namely, lower, middle and higher. Being in a higher wealth status, compared to the lower and middle was revealed to reduce the probability of occurrence of ARI. Therefore, the government should pay effort to raise the incomes of the poor and earmark funds that can facilitate individual access to healthcare irrespective of the ability to pay to overcome this situation.Overweight (BMI 25 kg/m2) is a growing problem which has been associated risk for acute respiratory infections [18].The incidence and severity of infectious illnesses are higher in obese persons than in lean persons. Acute respiratory infection is found to be the most significantly associated factor with malnutrition during childhood. In our study, the incidence of ARI was higher in stunted infants, wasted infants and infants that have low birth weight .Stunting is related to the long time exposure to poor environmental conditions and low socioeconomic status in childhood [19].The frequent and longer episodes of ARI may cause the retardation of growth. Moreover, other nutritional disorders are also associated with ARI. Presence of malnutrition was significantly associated with ARI in the present study, similar to other studies [15]. A study in the Philippines included age stratified risks in children less than 23 month of age and reported highest risk of death from ARI due to malnutrition among those aged 12-22 month [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 is associated with a two to three fold increase in mortality from ARI [20].

**Conclusion:**

The current study yields solid evidence that biomass fuel significantly increases children’s risk of ARI in Bangladesh. Despite the limitations discussed above, 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 biomass fuel is a main driver of ARI in Bangladesh. This finding underscores the need to improve 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 the double. Government should invest greater resources in ARI prevention and control, and explicitly consider ARI as a top priority phase and scenario.

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