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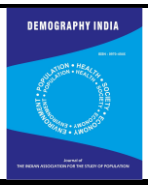

Identifying the prevalence and contextual determinants of Acute Respiratory Infection among rural children: A cross-sectional study in Purba Bardhaman district of West Bengal, India

Koustav Ghosh[1]* and Atreyee Sinha Chakraborty[2]

Abstract

Acute Respiratory Infection (ARI) remains a leading cause of morbidity and mortality among Under-five (U5) children in developing countries. A micro-level cross-sectional study conducted in 2022 to examine the prevalence and contextual risk factors of ARI in the Purba Bardhaman district of rural West Bengal, India. Primary data were collected from 296 households using a structured questionnaire. Multivariable logistic regression analysis revealed several significant risk factors. The prevalence of ARI in the study area was found to be 17.6 percent. Children living near muri mills (AOR: 2.2; 95% CI: 1.22–2.79), having contact with domestic animals (AOR: 3.3; 95% CI: 1.17–9.35), and with a family history of respiratory illness (AOR: 9.94; 95% CI: 2.97–33.3) were at higher risk. Cooking inside non-separate kitchens (AOR: 1.47; 95% CI: 1.13–6.5) and the child's presence during cooking (AOR: 6.54; 95% CI: 1.67–25.73) also increased ARI odds. Maternal respiratory illness (AOR: 3.58; 95% CI: 1.04–12.31) and being a female gender of the child (AOR: 2.49; 95% CI: 1.1–5.62) were identified as significant factors. It was also found higher household income reduces ARI risk. These findings provide critical insights into localized determinants of ARI, often missed in national surveys, and can inform targeted interventions to support child health and meet Sustainable Development Goal (SDG) 3.2.1.

Keywords

Acute Respiratory Infection, Morbidity, Prevalence, West Bengal

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Introduction

Acute Respiratory Infection (ARI) constitutes a major challenge to the public health system, especially in developing countries, and is one of the leading causes of morbidity and mortality among children under five years of age (Yadav et al., 2013; Gahlot et al., 2015). ARIs are airway infections, from the nostrils to the alveoli (Ghimire et al., 2022). It is defined as breathing faster than usual with short, quick breaths or difficulty in breathing but excludees the children with only a blocked nose (WHO, 2022a). ARIs are divided into two types: upper respiratory tract infections (URIs) and lower respiratory tract infections (LRIs) (Simoes et al., 2011). According to the Global Burden of Disease (GBD) study 2019, lower respiratory infection is the second leading cause of U5 mortality worldwide. In low and middle-income countries (LMICs), a substantial proportion of childhood deaths are attributed to easily preventable and treatable illnesses such as ARI, diarrhoea, and malaria (WHO, 2022b). According to the Global Burden of Disease (GBD) report in 2018, a lower respiratory infection is responsible for approximately 704,000 deaths among children under the age of five years (GBD, 2018). Moreover, the highest rates of ARI are observed in the regions of Southeast Asia and Africa (Anteneh & Hassen, 2020; Troeger et al., 2018). ARI is the major cause of mortality among children aged less than 5 years, especially in low-income (Walker et al., 2013) and developing countries (Frese et al., 2011) like India (Selvaraj et al., 2014). It is estimated that Bangladesh, India, Indonesia, and Nepal together account for 40% of the global ARI mortality (Kumar et al., 2015). India is listed among the top 15 nations facing the highest rates of pneumonia incidents and associated mortality among children (Troeger et al., 2018; Hasan et al., 2022). Every year, about 400,000 children U5 years of age succumb to diseases related to ARI in India (Hasan et al., 2022).

Various factors can influence the ARI in children. These include the type of housing, parental smoking history, respiratory infections among family members, nutritional status of the children, and the type of cooking fuel used in the household (Tazinya et al., 2018; Nair et al., 2013; Naz & Agho, 2017; Langbein, 2017; Amha & Worku, 2018). Moreover, the studies from India found that the prevalence of ARI is relatively higher among young children, children who suffer from anaemia, low birth weight, and those who are not non-exclusively breastfed (Budge et al., 2014; Hasan & Richardson, 2017; Prajapati et al., 2012; Hussain et al., 2014).

The Sustainable Development Goals (SDGs 3.2.1) aim to reduce the deaths from preventable diseases among new-born babies and children U5 years by the year 2030. (Dahan & Gelb, 2015). Despite of various efforts by International and National agencies to control and prevent childhood diseases like diarrhoea, pneumonia and ARI, still a large number of children from varied backgrounds are suffering from these preventable diseases that eventually lead to unprecedented levels of child mortality and morbidity in developing countries, including India (Van Esterik, 2002; Bang & Tiwari, 2011; Tiwari et al., 2016). The Indian large-scale data, National Family Health Survey (NFHS-V, 2019-21) indicates that the prevalence of ARIs has increased 2.7 percent to 2.8 percent between the year 2016 to 2019 (IIPS, 2021). According to the Household Survey (DLHS-III, 2007-08), the state, West Bengal in India reported the highest

prevalence of ARI among children (25%) (Prakash, 2014; DLHS-III, 2007-08). In rural West Bengal, ARI were the most frequent reason behind morbidity (38.6%) present in the population, followed by undernutrition (27.7%), pallor (27.7%), worm infestation (14.9%), skin disease (12.8%), and diarrhea (12.8%) (Paramanik et al., 2015). Recent research highlighted that bidi consumption is highly prevalent in the states of West Bengal, Himachal Pradesh, Haryana, Uttarakhand, and Madhya Pradesh, which is one of the reasons behind the location of most of the hotspot districts of ARI in those states (Balasubramani et al., 2022). Tobacco consumption and smoking behaviors, indoor air pollution, are important risk factors for ARI (Balasubramani et al., 2022; Mueller et al., 2011). The high population density of West Bengal (>800 persons per Km^2) increases the risk of ARI (Balasubramani et al., 2022; Mueller et al., 2011). However, the high prevalence of ARI among the U5 children in the state of West Bengal requires some micro-level analysis to find out the casual relations. So, we have chosen the Purba Bardhaman district from West Bengal as our study area. The ARI prevalence among U5 children in this district is 5 percent which surpasses the national average (2.8%) and it is the second-highest prevalence among the districts from West Bengal followed by Haora district. (5.6%). The present study aims to show the prevalence of ARI and its contextual risk factors in the Purba Bardhaman district of West Bengal, India. Our study being the micro level analysis includes the variables like location of household (within 1 km range from poultry firm, rice mill, muri mill), household members contact with pet/domestic animals, presence of child during cooking, diarrhoea episode (in last 1 year) etc. to find out the contextual determinants which are not incorporated in the large scale survey like NFHS and expects to come out with the some of the relevant determinants of prevalence of ARI among children. Those determinants yet unexplored in the Indian context, or specifically in the context of the study area, can be helpful to policymakers for controlling the prevalence issues of ARI among children.

Data Source and Methodology

Data collection

We have collected primary data from Purba Bardhman district of rural West Bengal. The primary data has been collected with the help of a structured questionnaire. The questionnaire schedule includes information related to household environment, maternal and child characteristics. The data collection permission was granted by university's authority, after reviewing the questionnaires on 1 August 2022. Consent was taken from every selected respondent before the data collection. Sample size calculation

We estimated the sample size for the study in Purba Bardhman by considering the prevalence of ARI. The total calculated sample for the study is 288. Considering a 10 percent non-response rate, we have collected 302 samples for the study. We had to exclude six samples because they refused to answer. So, finally, we have 296 samples for the final analysis.

Formula

$$\text{Sample Size (N)} = \frac{z^2 * p(1-p)}{\varepsilon^2}$$

$$N = \frac{3.86^2 * 0.05(1-0.05)}{0.05^2}$$

$$N = 288$$

Final Sample Size =288+14 (by taking 5% non-response rate)

=302

Whereas,

N is the population size
Z is the z-score
p̂ is the estimated prevalence of the study area (5%)
ε is the margin of error (5%)

Rationale for Selecting Villages and AWCs

According to the 2011 Census, the Monteswar block comprised 144 villages. Villages with fewer than 100 households (n=20) were excluded to ensure adequate population coverage. From the remaining villages, one was randomly selected as the starting point, and 11 adjacent villages were chosen to form a cluster of 12 villages (Figure 1), thereby optimizing cost and time efficiency. Within each village, the Anganwadi Centre (AWC) with the highest enrolment was selected to facilitate the identification of U5 children. The required sample was then allocated across these 12 AWCs using the Probability Proportionate to Size method, and eligible children were selected through simple random sampling without replacement.

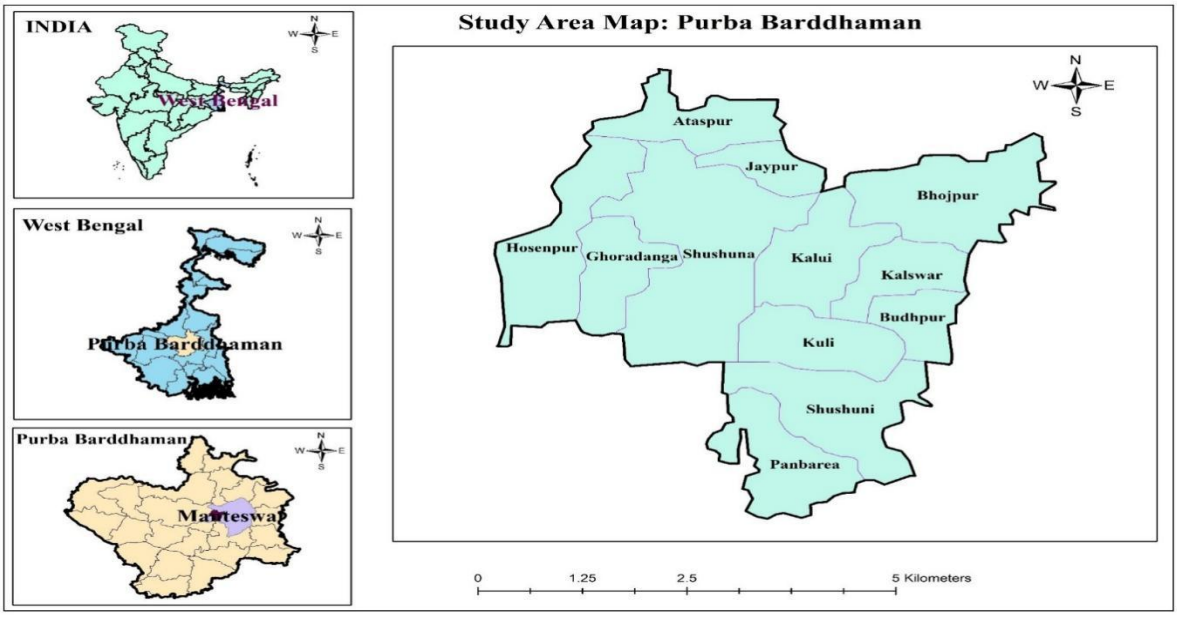

Figure1 Study area

Selection of respondents

We have decided to examine the responses provided by mothers to their children aged less than 5. In instances where mothers have more than two children within this specified age group, we have selected the youngest child.

Computation of ARI Prevalence among under-five children

Prevalence of ARI is defined as the "number of U5 children suffering from symptoms of ARI at any time in the 2 weeks preceding the survey out of the total number of living children less than 5 years of age" (NFHS). According to the NFHS definition, ARI consists of a cough accompanied by:

a. Short, rapid breathing that is chest-related, and/or

b. Difficult breathing that is chest-related.

Prevalence of ARI

$$= \frac{Number\ of\ children\ under\ age\ 5\ with\ symptoms\ of\ ARI\ at\ any\ time\ in\ the\ 2\ weeks\ preceding\ the\ survey}{Number\ of\ living\ children\ under\ age\ 5} \times 100$$

Outcome Variable

In the primary survey tools, mothers were asked if their children under the age of five had experienced a cough in the two weeks before the survey, as suggested by NFHS. This type of cough is characterized by quick, shallow breaths and chest discomfort. If the response was "yes," the corresponding variable was marked as 1, indicating the presence of Acute Respiratory Infection (ARI). If the response was "no," it was labeled as 0, indicating no ARI.

Explanatory Variable

A set of explanatory variables (i.e., household environmental characteristics, socio-economic characteristics, maternal characteristics and children characteristics) were collected through primary survey to identify the risk factors associated with ARI in the study district.

Household environmental characteristics: It includes type of house (pucca/semi Pucca/kachha). The location of the household within 1 km range of pucca road (yes/no), poultry firm (yes/no), muri mill (yes/no), and near rice mill (yes/no) were also included in the study. Additionally, contact with pet/domestic animals (yes/no), source of alternative light during unavailability of electricity (kerosene lamp/emergency light), smoking habit among members in the Household (yes/no), Family History of Respiratory Illness (yes/no), Main source of cooking fuel (firewood, kerosene, coal, and charcoal/cow dung cakes/ LPG/natural gas pipeline), Place of cooking (cooking in a separate kitchen/Cooking inside the house without a separate kitchen/ cooking in the open or outside the house), Frequency of cooking in a day (once/twice/more), and presence of child during cooking (not present/sometimes/most of the time) were also considered.

Socio economic characteristics: It includes religion (hindu/muslim), social category (SC or ST/OBC/general), PDS/ration card type (APL/BPL), type of family (joint family/nuclear family/extended family), and family annual income (< Rs. 50,000/Rs. 50,000 to 75,000/> Rs. 75,000)

Maternal characteristics: Maternal characteristics includes mother's age (< 20 years/20 - 24 years/25 - 29 years/> 29 years), education (primary/secondary/higher secondary and above), total number of children (one children/two children/more than two children), mother's respiratory illness in last 2 weeks (yes/no), mass media exposure (yes/no)

Children characteristics: child age (0-11 months/12-23 months/24-35 months/36-47 months/48-59 months), sex of the child (male/female), birth weight of child (low birth weight/normal birth weight), occurrence of diarrohea in the last 2 weeks (yes/no), diarrohea episode in last 1 year (no episode/single episode/two or more episodes).

Statistical Analysis

The study used descriptive statistics and bivariate analysis, including the Chi-square test, to obtain initial results. Multivariable logistic regression models were used to identify the factors associated with ARI among children in the study area. The mathematical expression of the logistic regression analysis is:

$$\boldsymbol{logit}(\boldsymbol{P}) = [\ln P/(1-P)] = \beta_0+\beta_1 X_1 + \beta_2 X_2 + \ldots\ldots\ldots\ldots + \beta_k X_k$$

Let P be the probability of an event (suffering from ARI), which is influenced by a set of predictor variables with coefficients β0, β1, β2, and so on (βk) and predictor variables X1, X2, and so on (Xk). The ratio of P to (1-P) represents the odds, and the log of this ratio is the logit of P. We used dichotomous logit to estimate the dependent variables and considered significance levels of 1%, 5%, and 10% for all statistical tests. All analyses were performed using STATA version 14.

Results

Prevalence of ARI among children with the background characteristics

In our study area, among the 296 U5 children surveyed, 52 children (17.6%) were reported to be suffering from ARI (Table 1) during the two weeks preceding the survey, while the remaining 244 children (82.4%) did not exhibit symptoms of the disease **(Figure 2)**

Figure 2 Prevalence of ARI among U5 children in the Purba Bardhman district of West Bengal in 2022

Table 1 & 2 presents the prevalence of ARI among children according to various background characteristics. The chi-square test was used to examine the relationship between ARI and these factors.

The prevalence of ARI among children varied according to environmental and household factors. Children residing within one kilometre of a pucca road exhibited a higher prevalence of ARI (20%) compared to those living farther away. The prevalence was even greater among children living near a rice mill, reaching 35%. Household-level exposures also influenced ARI prevalence; children from households with contact with pets or domestic animals reported a prevalence of 24%, higher than that observed among children without such contact. Additionally, households relying on kerosene as an alternative light source during electricity outages reported a similar prevalence of 24%. These findings indicate that both environmental proximity and household practices are associated with an increased risk of ARI in children. The presence of smokers within the household was associated with a higher prevalence of acute respiratory infections (ARI) among children, at 22%. Similarly, children with a family history of respiratory illness exhibited a markedly higher prevalence of 38%. The location of cooking within the household was also an important factor: children from households cooking outside or in open spaces had the highest prevalence of ARI (26%), followed by those cooking inside the house but not in a separate kitchen (17%). Households that cooked in a separate kitchen reported the lowest prevalence (13%). These findings suggest that both household smoking and cooking practices are significant determinants of ARI risk in children.

Among socio-economic factors, religion, caste, and income were significantly associated with ARI prevalence. Children from Hindu households had a higher prevalence (23%) compared to Muslim households (12%). Children from Scheduled Caste (SC) and Scheduled Tribe (ST) groups had the highest prevalence (27%), while children from the General caste and Other

Backward Classes (OBC) had lower prevalence rates of 20% and 10%, respectively. Families with an annual income below Rs. 50,000 showed the highest prevalence of ARI (52%), and the prevalence decreases with higher income levels.

As far as mother's health is concerned, children whose mothers had respiratory illness in the last two weeks had a higher prevalence of ARI (33%) compared to others (15%). Among child characteristics, girls had a higher prevalence (22%) than boys (14%). Low birth weight babies had shown double the prevalence (30%) compared to those with normal birth weight (15%).

The presence of children during cooking also influenced the prevalence of ARI. Children who were not present during cooking had the lowest prevalence (12%), whereas those present sometimes or most of the time exhibited higher prevalence rates of 18% and 27%, respectively. Socioeconomic factors were similarly associated with ARI risk. Households holding Below Poverty Line (BPL) ration cards reported a lower prevalence (15%) compared to Above Poverty Line (APL) households (20%). Family structure also played a role, with nuclear families showing the lowest prevalence (12%), followed by joint (18%) and extended families (24%).

Maternal characteristics were important determinants of ARI. Children of mothers over 29 years of age had the lowest prevalence (13%), while those of very young mothers (under 20 years) had the highest prevalence (31%). Maternal education showed a clear gradient: children of mothers with higher secondary education or above had the lowest prevalence (10%), whereas those with less than primary schooling had the highest prevalence (21%). Additionally, family size appeared to influence ARI prevalence, with families having more than two children showing the lowest prevalence (8%), while single-child families had the highest (21%).

Interestingly, children of mothers without mass media exposure had lower ARI prevalence (14%) compared to those with exposure (20%). Child's age and recent episodes of diarrhoea were not significantly related to ARI. However, very young children under 12 months had the lowest prevalence (12%), and the oldest group (48-59 months) had the highest (22%). Children who experienced more than two episodes of diarrhoea over a one-year period demonstrated a higher prevalence of ARI (28%) compared to their counterparts with fewer or no diarrhoeal episodes.

Table 1 Distribution of sample across study variables

Background Characteristics	Distribution of Sample *N (%)*
The child had ARI (in the last 2 weeks)	
No	244 (82.4)
Yes	52 (17.6)
A. Household Environment	
Type of House	
Pucca	126 (42.5)
Semi Pucca	59 (20)
Kachha	111 (37.5)

Located Pucca Road (within 1Km)	
No	51 (17.3)
Yes	245 (82.7)
Poultry firm (within 1Km)	
No	268 (90.5)
Yes	28 (9.5)
Muri mill (within 1Km)	
No	248 (83.7)
Yes	48 (16.3)
Rice Mill (within 1Km)	
No	270 (91.3)
Yes	26 (8.7)
Contact with pet/domestic animals	
No	135 (45.6)
Yes	161 (54.4)
Source of Alternative light during the unavailability of electricity	
Kerosene lamp	129 (43.5)
Emergency light	167 (56.5)
Smoking anyone in the Household	
No	112 (37.9)
Yes	184 (62.2)
Family History of Respiratory Illness	
No	251 (84.8)
Yes	45 (15.3)
The main source of cooking fuel	
Firewood/ Kerosene/ Coal, and charcoal	55 (18.6)
Cow dung cakes	142 (48)
LPG/Natural Gas Pipeline	99 (33.5)
Place of cooking	
Cooking in a separate kitchen	152 (51.4)
Cooking inside the house, but not in a separate kitchen	47 (15.9)
Cooking in the open/ outside the house	97 (32.8)
Frequency of cooking in a day	
Once	36 (12.2)
Twice	228 (77.1)
More	32 (10.9)
Presence of the child during cooking	
No	70 (23.7)
Sometimes	181 (61.2)
Most of the time	45 (15.3)
B. Socio-economic Characteristics	
Religion	
Hindu	152 (51.4)
Muslim	144 (48.7)

Social Category (Caste)	
SC & ST	77 (26.1)
OBC	125 (42.3)
General	94 (31.8)
PDS/Ration card type	
APL	151 (51.1)
BPL	145 (49)
Type of family	
Joint	95 (32.1)
Nuclear	105 (35.5)
Extended	96 (32.5)
Family Income (Per Years)	
< Rs. 50,000	46 (15.6)
Rs. 50,000 to 75,000	162 (54.8)
> Rs. 75,000	88 (29.8)
C. Mother's Characteristics	
Mother's Age	
< 20 years	23 (7.8)
20 - 24 years	127 (43)
25 - 29 years	100 (33.8)
> 29 years	46 (15.6)
Mother's Education	
Primary	99 (33.5)
Secondary	125 (42.3)
Higher Secondary and above	72 (24.4)
Total number of children	
One Children	145 (49)
Two Children	125 (42.3)
More than two children	26 (8.8)
Mother Suffering from respiratory illness in the last 2 weeks	
No	251 (84.8)
Yes	45 (15.3)
Mass media exposure	
No	95 (32.1)
Yes	201 (68)
D. Children Characteristics	
Child age (in months)	
< 12 Months	41 (13.9)
12-23 Months	73 (24.7)
24-35 Months	78 (26.4)
36-47 Months	49 (16.6)
48-59 Months	55 (18.6)
Sex of the child	
Boy	156 (52.8)
Girl	140 (47.3)

Child weight during birth/birth weight of child	
Normal (>2.50 KG)	246 (83.2)
Low birth weight (<2.50 KG)	50 (16.9)
The child had diarrohea (in the last 2 weeks)	
No	278 (94)
Yes	18 (6.1)
Diarrohea Episode (in last 1 year)	
No Episode	136 (46)
Single Episode	70 (23.7)
Two or More Episodes	90 (30.5)

Table 2 Prevalence of ARI with background characteristics

Background Characteristics	Prevalence of ARI N (%)
A. Household Environment	
Type of House	*χ2 = 2.5; p=0.284*
Pucca	17 (13.5)
Semi Pucca	12 (20.4)
Kachha	23 (20.8)
Located Pucca Road (within 1Km)	*χ2 = 4.02; p=0.045**
No	4 (7.9)
Yes	48 (19.6)
Poultry firm (within 1Km)	*χ2 = 2.6; p=0.108*
No	44 (16.5)
Yes	8 (28.6)
Muri mill (within 1Km)	*χ2 = 1.42; p=0.516*
No	42 (17)
Yes	10 (20.9)
Rice Mill (within 1Km)	*χ2 = 5.72; p=0.017**
No	43 (16)
Yes	9 (34.7)
Contact with pet/domestic animals	*χ2 = 10.8; p<0.001***
No	13 (9.7)
Yes	39 (24.3)
Source of Alternative light during the unavailability of electricity	χ2 = 6.6; p=0.010*
Kerosene lamp	31 (24.1)
Emergency light	21 (12.6)
Smoking anyone in the Household	χ2 = 7.46; p=0.006**
No	11 (9.9)
Yes	41 (22.3)

Family History of Respiratory Illness	$\chi2 = 14.97$; $p<0.001$***
No	35 (14)
Yes	17 (37.8)
The main source of cooking fuel	$\chi2 = 3.29$; $p=0.194$
Firewood/ Kerosene/ Coal, and charcoal	10 (18.2)
Cow dung cakes	30 (21.2)
LPG/Natural Gas Pipeline	12 (12.2)
Place of cooking	$\chi2 = 7.251$; $p=0.027$*
Cooking in a separate kitchen	19 (12.5)
Cooking inside the house, but not in a separate kitchen	8 (17.1)
Cooking in the open/ outside the house	25 (25.8)
Frequency of cooking in a day	$\chi2 = 0.46$; $p=0.793$
Once	6 (16.7)
Twice	39 (17.2)
More	7 (21.9)
Presence of the child during cooking	$\chi2 = 4.40$; $p=0.111$
No	8 (11.5)
Sometimes	32 (17.7)
Most of the time	12 (26.7)
B. Socio-economic Characteristics	
Religion	$\chi2 = 6.43$; $p=0.011$*
Hindu	35 (23.1)
Muslim	17 (11.9)
Social Category (Caste)	$\chi2 = 10.94$; $p=0.004$**
SC & ST	21 (27.3)
OBC	12 (9.6)
General	19 (20.3)
PDS/Ration card type	$\chi2 = 1.12$; $p=0.289$
APL	30 (19.9)
BPL	22 (15.2)
Type of family	$\chi2 = 5.45$; $p=0.066$
Joint	17 (17.9)
Nuclear	12 (11.5)
Extended	23 (24)
Family Income (Per Years)	$\chi2 = 46.84$; $p<0.001$***
< *Rs. 50,000*	24 (52.2)
Rs. 50,000 to 75,000	22 (13.6)
> *Rs. 75,000*	6 (6.9)
C. Mother's Characteristics	
Mother's Age	$\chi2 = 5.10$; $p=0.164$
< *20 years*	7 (30.5)
20 - 24 years	18 (14.2)
25 - 29 years	21 (21)
> *29 years*	6 (13.1)
Mother's Education	$\chi2 = 4.20$; $p=0.123$

Primary	21 (21.3)
Secondary	24 (19.2)
Higher Secondary and above	7 (9.8)
Total number of children	$\chi2$ = 2.94; p=0.230
One Children	30 (20.7)
Two Children	20 (16)
More than two children	2 (7.7)
Mother Suffering from respiratory illness in the last 2 weeks	$\chi2$ = 9.10; p=0.003**
No	37 (14.8)
Yes	15 (33.4)
Mass media exposure	$\chi2$ = 1.45; p=0.227
No	13 (13.7)
Yes	39 (19.5)
D. Children Characteristics	
Child age (in months)	$\chi2$ = 1.91; p=0.752
< 12 Months	5 (12.2)
12-23 Months	14 (19.2)
24-35 Months	12 (15.4)
36-47 Months	9 (18.4)
48-59 Months	12 (21.9)
Sex of the child	$\chi2$ = 3.84; p=0.050*
Boy	21 (13.5)
Girl	31 (22.2)
Child weight during birth/birth weight of child	$\chi2$ = 6.42; p=0.011*
Normal (>2.50 KG)	37 (15.1)
Low birth weight (<2.50 KG)	15 (30)
The child had diarrohea (in the last 2 weeks)	$\chi2$ = 0.29; p=0.59
No	48 (17.3)
Yes	4 (22.3)
Diarrohea Episode (in last 1 year)	$\chi2$ = 16.27; p<0.001***
No Episode	11 (8.1)
Single Episode	16 (22.9)
Two or More Episodes	25 (27.8)

*Note: Prevalence of ARI: Row percentage. ARI Prevalence: 0=not suffered from ARI, 1=suffered from ARI, Chi-square test: p < 0.05 (***p<0.001, **p<0.01, *p<0.05) =significant*

Risk factors associated with ARI among children in Purba Bardhman district of West Bengal, India

Table 3 represents Logistic regression model assessing household environmental and other socio-economic characteristics associated with ARI among children (0-59 Months) in a rural part of West Bengal, India (2022). The findings indicated that households near the muri mill (within a 1 km range) were associated with an increased risk of childhood ARI (AOR: 2.2; 95% CI: 1.22-2.79) compared to households located away from the mill. Further, household members who had contact with pets/domestic animals showed a 3.3 times higher risk of ARI for their children (AOR: 3.3, 95% CI: 1.17-9.35) than those without such contact. Family history of respiratory

illness was also significantly increased the odds of childhood ARI by 9.94 times (AOR: 9.94, 95% CI: 2.97-33.3) compared to households without a history of respiratory illness. Cooking inside the house without a separate kitchen was associated with an increased risk of childhood ARI (AOR: 1.47, 95% CI: 1.13-6.5) compared to cooking in a separate kitchen. Additionally, the presence of a child, especially with the mother, during cooking was identified as a significant contributing factor to childhood ARI (AOR: 6.54, 95% CI: 1.67-25.73).

In terms of socio-economic characteristics, the study found that higher household income was associated with a reduced prevalence of childhood ARI. Households with an annual income ranging from Rs. 50,000 to 75,000 (AOR: 0.07, 95% CI: 0.02-0.46) and >Rs. 75,000 (AOR: 0.04; 95% CI: 0.01-0.33) were found to have a reduced risk of childhood ARI compared to households with an income less than a certain threshold.

Regarding maternal characteristics, the study highlighted that a mother's recent respiratory illness increased the odds of her children having ARI (AOR: 3.58; 95% CI: 1.04-12.31) compared to mothers without recent respiratory illness.

Finally, the study revealed that female children (AOR: 2.49; 95% CI: 1.1-5.62) were more likely to suffer from ARI compared to male children. These findings shed light on the complex interplay of environmental, socio-economic, and maternal factors associated with childhood ARI in rural West Bengal, India.

Table 3 Logistic regression model assessing household environmental and other socio-economic characteristics associated with ARI among U5 children in a rural part of West Bengal, India (2022)

Background Characteristics	AOR 95% of CI [Lower-Upper]	p value
A. Household Environment		
Type of house		
Pucca	*Ref.*	
Semi pucca	1.17 [0.26-5.35]	0.839
Kachha	0.71 [0.21-2.36]	0.579
Located pucca road (within 1Km)		
No	*Ref.*	
Yes	2 [0.24-17.16]	0.525
Poultry firm (within 1Km)		
No	*Ref.*	
Yes	0.37 [0.03-6.26]	0.466
Muri mill (within 1Km)		
No	*Ref.*	
Yes	2.2 [1.22-2.79]	<0.001
Rice mill (within 1Km)		
No	*Ref.*	
Yes	1.03 [0.08-14.06]	0.982
Contact with pet/domestic animals		
No	*Ref.*	
Yes	3.3 [1.17-9.35]	0.024

Source of alternative light during unavailability of electricity		
Kerosene lamp	*Ref.*	
Emergency light	0.48 [0.21-1.14]	0.089
Smoking anyone in the household		
No	*Ref.*	
Yes	3.26 [0.83-12.84]	0.091
Family history of respiratory illness		
No	*Ref.*	
Yes	9.94 [2.97-33.31]	<0.001
The main source of cooking fuel		
Firewood/ Kerosene/ Coal and charcoal	*Ref.*	
Cow dung cakes	0.38 [0.09-1.58]	0.186
LPG/Natural Gas Pipeline	0.5 [0.09-2.88]	0.433
Place of cooking		
Cooking in a separate kitchen	*Ref.*	
Cooking inside the house, but not in the separate kitchen	1.47 [1.13-6.57]	0.004
Cooking in open/ outside house	1.06 [0.27-4.18]	0.934
Frequency of cooking in a day		
Once	*Ref.*	
Twice	1.37 [0.28-6.75]	0.698
More	1.07 [0.15-8]	0.947
Presence of the child during cooking		
No	*Ref.*	
Sometimes	1.52 [0.35-6.64]	0.577
Most of the time	6.54 [1.67-25.73]	0.007
B. Socio-economic Characteristics		
Religion		
Hindu	*Ref.*	
Muslim	1.55 [0.26-9.55]	0.634
Social category (Caste)		
SC & ST	*Ref.*	
OBC	0.3 [0.05-1.94]	0.197
General	1.65 [0.32-8.49]	0.549
PDS/Ration card		
APL	*Ref.*	
BPL	1.7 [0.45-6.42]	0.434
Type of family		
Joint	*Ref.*	
Nuclear	0.59 [0.12-2.97]	0.519
Extended	2.02 [0.63-6.55]	0.239
Family income (per year)		
< Rs. 50,000	*Ref.*	
Rs. 50,000 to 75,000	0.07 [0.02-0.46]	0.001
> Rs. 75,000	0.04 [0.01-0.33]	0.001
C. Mother's characteristics		
Mother's age		

< 20 years	*Ref.*	
20 - 24 years	0.77 [0.2-2.98]	0.704
25 - 29 years	1.48 [0.26-8.48]	0.659
> 29 years	0.76 [0.07-8.26]	0.822
Mother's education		
Primary	*Ref.*	
Secondary	1.57 [0.38-6.56]	0.535
Higher secondary and above	1.02 [0.16-6.68]	0.983
Total number of children		
One child	*Ref.*	
Two children	0.72 [0.27-1.91]	0.510
More than two children	0.24 [0.02-3.09]	0.267
Mother Suffering from respiratory illness for the last 2 weeks		
No	*Ref.*	
Yes	3.58 [1.04-12.31]	0.043
Mass media exposure		
No	*Ref.*	
Yes	0.65 [0.19-2.26]	0.495
D. Children Characteristics		
Child age (in months)		
< 12 months	*Ref.*	
12-23 months	1.37 [0.17-11.17]	0.768
24-35 months	0.87 [0.1-7.97]	0.901
36-47 months	1.44 [0.17-12.56]	0.740
48-59 months	1.77 [0.22-14.36]	0.592
Sex of the child		
Boy	*Ref.*	
Girl	2.49 [1.1-5.62]	0.028
Child weight during birth		
Normal (>2.50 KG)	*Ref.*	
Low birth weight (<2.50 KG)	0.82 [0.26-2.56]	0.734
The child had diarrohea (in the last 2 weeks)		
No	*Ref.*	
Yes	1.32 [0.26-6.69]	0.738
Diarrohea episode (in last 1 year)		
No episode	*Ref.*	
Single episode	2.93 [0.85-10.14]	0.089
Two or more episodes	1.68 [0.63-4.52]	0.302
Overall Model Evolution		
Number of Observations (N)	296	
Log-likelihood	-78.864211	
Likelihood Ratio (LR) Chi-square ($\chi 2$)	117.42	
Chi-square ($\chi 2$) p value	<0.001	
Pseudo R2	0.4267	

Note: *AOR: Adjusted Odds Ratio, Ref: Reference Category, CI: Confidence interval, p-value: < 0.05 is generally considered statistically significant; SC: Scheduled Caste, ST: Scheduled Tribe, OBC: Other Backward Caste.*

Discussion

The present study indicates that the overall prevalence of acute respiratory infections (ARI) among children in Purba Bardhmaan district is 17.6 percent. This finding is consistent with national-level estimates in India and reflects a moderate burden of ARI in this region. Our study highlights several household, environmental, maternal, and socioeconomic factors associated with childhood ARI, which provide valuable insights for targeted interventions.

Among the household environmental factors, our research indicates that households located near the Muri and Rice mills are at an elevated risk of childhood ARI. These findings align with prior research demonstrating that exposure to organic and inorganic dust, as well as synthetic chemicals, in the vicinity of mills can exacerbate respiratory morbidity in children (Ghosh et al., 2014; Rana et al., 2018). In addition, children living in households where the members have contact with pets or domestic animals show a greater risk of ARI compared to those without such contact. Our findings were similar to those of a study conducted in Haryana, India, which found that passive smoking and pets at home were factors associated with the presence of asthma symptoms (Hassen et al., 2020). Furthermore, cooking inside a non-separate kitchen, and particularly in the presence of a child, especially with the mother, during food preparation constitutes a significant contributing factor to childhood acute respiratory infections. These findings align with previous studies indicating that exposure of household to smoke can elevate children's risk of respiratory infections due to passive smoking (Mandal et al., 2020; Varghese & Muhammad, 2023). Additionally, having a separate room as a kitchen can help in preventing children from inhaling smoke, which can be particularly harmful if solid fuels are used for cooking (Savitha & Gopalakrishnan, 2018; Varghese & Muhammad, 2023).

In the context of maternal characteristics, our study finds that children of mothers with respiratory diseases or asthma are more likely to get ARI compared to those without these conditions which matches the findings from the previous research (Varghese & Muhammad, 2023; Ramani et al., 2016; Prajapati et al., 2012). The possible reason may be that since children typically spend most of their time indoors, they are more vulnerable to contracting infections from family members with respiratory illnesses (Savitha & Gopalakrishnan, 2018).

Our study also shows the association between socioeconomic factors and ARI. Children from middle and higher-income households exhibit a reduced risk of contracting ARI as compared to those from lower-income households. Existing research also suggests that children from rural areas and low-income families face an elevated risk of ARI (Sultana et al., 2019). This heightened susceptibility has been linked to the disadvantaged socioeconomic status of households in rural settings, aligning with comparable findings from other low- and middle-income countries (Sultana et al., 2019; Harerimana et al., 2016).

Mothers with respiratory illness/asthma were found to have a significant relationship with the development of their children's ARI. Our findings align with other studies, suggesting that maternal smoking increases the risk of ARI among children in India as well as rural West Bengal (Savitha et al., 2007; Ramani et al., 2016). Considering a child's characteristics, our study highlighted

that female children were more likely to suffer from ARI compared to male children. Our findings are consistent with previous research (Gupta et al., 2014; Pandey et al., 2002). Gender disparities in healthcare-seeking behavior may influence the diagnosis and reporting of ARI cases. Females may have different access to healthcare services, leading to variations in reported prevalence rates (Pandey et al., 2002). Based on our findings, several targeted interventions can be recommended to reduce the burden of ARI among under-five children in rural West Bengal. Promoting indoor ventilation by encouraging the use of separate kitchens or improved cooking areas can significantly reduce exposure to indoor air pollutants, a known risk factor for respiratory infections. Strengthening female child nutrition programs is crucial, as undernutrition increases susceptibility to infections, including ARI. Additionally, community-based awareness campaigns focusing on early recognition of ARI symptoms, timely healthcare-seeking behavior, and preventive practices such as hand hygiene and avoiding indoor smoke exposure can help mitigate disease prevalence. Implementing these measures in an integrated manner may improve overall child health outcomes and reduce gender disparities in ARI incidence.

Our study has several limitations that must be acknowledged: Firstly, the study uses a cross-sectional design, capturing information at a single point in time. This limits the ability to establish causal relationships between risk factors and ARI prevalence. Secondly, the study is limited to a specific district (Purba Bardhaman) in rural West Bengal. Therefore, the findings may not be generalizable to other districts in West Bengal or other states of India, especially urban areas or regions with differing socioeconomic and environmental conditions. Thirdly, information collected through structured questionnaires may be subject to recall bias or social desirability bias, particularly on sensitive issues like smoking behaviors, fuel use, or child illness episodes. Fourthly, villages with fewer than 100 households were excluded from the study, which may have led to under representation of smaller and possibly more vulnerable rural communities where health indicators could differ significantly. Lastly, the study focuses on micro-level determinants that are not included in large-scale surveys like the NFHS. Though this adds depth, it also limits the ability to directly compare findings with broader national datasets.

Conclusion

This study highlights the high prevalence of ARI among U5 children in Purba Bardhaman district, West Bengal, at 18 percent, which is significantly higher than the national average. Our findings emphasize that multiple contextual factors influence the risk of ARI in children. Household environmental factors, such as proximity to rice and muri mills, contact with domestic animals, and cooking practices (especially cooking inside a non-separate kitchen with child presence), are significant contributors to ARI risk. Maternal health also plays a critical role; children of mothers with respiratory illnesses are more vulnerable to ARI, likely due to close indoor contact increasing infection transmission. Socioeconomic status further affects ARI prevalence, with children from lower-income families being at greater risk. Female children were found to have a higher likelihood of contacting ARI compared to males, indicating possible gender disparities

in health outcomes. These findings align with existing literature and underscore the importance of addressing environmental, maternal, and socioeconomic factors to reduce ARI prevalence. Overall, this micro-level study provides valuable insights beyond large-scale surveys, identifying specific determinants relevant to the local context. Policymakers and healthcare providers can use these findings to develop targeted interventions aimed at improving child respiratory health, particularly in vulnerable rural communities.

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