e-ISSN: 0975-9506, p-ISSN: 2961-6093

Available online on www.ijpqa.com

International Journal of Pharmaceutical Quality Assurance 2025; 16(8); 504-510

Original Research Article

Acute Respiratory Infections in Children: Epidemiological Trends and Management Approaches

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Received: 10-06-2025 / Revised: 11-07-2025 / Accepted: 26-08-2025
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Conflict of interest: Nil

Abstract:

Background: Acute Respiratory Infections (ARI) continue to be the leading cause of morbidity and mortality in children worldwide, especially in low-resource settings like India. Despite improvements in access to healthcare and vaccines, ARI, particularly lower respiratory infections, continues to incur substantial health and financial burden.

Aim: The aim of this study was to understand the epidemiological trends, clinical features, and management of ARI in children ages 0-10 years in rural Jharkhand India.

Methodology: A one-year prospective observational cohort study one year of 300 children presenting to Sheikh Bhikhari Medical College and Hospital, Hazaribagh, Jharkhand was conducted. Outcomes including incidence, severity, and hospitalizations due to ARI were captured by weekly surveillance. Socio-demographic, environmental, and clinical variables were analyzed using descriptive and multivariate statistics.

Results: The overall incidence of ARI was 5.74 episodes/per child-year, with the highest rates in children less than 5 years of age (6.98/per child-year). Acute Lower Respiratory infections (ALRI) comprised 0.30 episodes per child year. Key risk factors identified were household use of biomass fuel (67.3%), household smoking (58.7%), and crowding. The incidence of hospitalization was low (0.05 episodes/per child-year), suggesting that there was predominately management of ARI in the community.

Conclusion: ARI is a significant health burden among children, especially children less than 5 years of age. Environmental exposures and socio-economic status are concrete factors relating to incidence of ARI. Enhancements in primary health care, reductions in indoor pollution, and improvements in housing conditions are all important components to address ARI prevention.

Keywords: Acute Respiratory Infection, Children, Epidemiology, Lower Respiratory Tract Infection, Public Health, India.

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Introduction

Acute Respiratory Infections (ARI) are among the most important global health issues, especially among the child population of the low- and middle-income world. In the developing world such as India, ARI remains a significant cause of child morbidity and mortality [1]. In spite of the developments of medical care, the state of the infrastructure of health of people, and immunization, ARI, particularly the infections that are related to the lower respiratory tract, remain one of the major killing diseases among children under the age of five [2]. ARI has been estimated to contribute to about 1.9 million deaths among children every year around the world with about 20 percent of it in India alone [3]. These statistics are important not only to highlight the scale of the issue, but also the urgent necessity of context-related epidemiological and clinical expertise to lead the intervention measures.

Acute Respiratory Infections include a broad range of diseases, including mild upper respiratory tract infections (URTIs), including common cold and pharyngitis, as well as severe lower respiratory tract infections (LRTIs), including pneumonia and bronchiolitis. Around 85-88 percent of the total ARI episodes worldwide are Attack Upper Respiratory Infections (AURI), with the remaining percentage being the Acute Lower Respiratory Infections (ALRI) [4]. However, lower respiratory infections are the most significant source of morbidity, mortality and long-term health outcome in children even though upper respiratory infections are more prevalent. Of them, pneumonia is the most severe case, which is estimated to cause 369000 deaths in India alone every year- 28 percent of all deaths of children under age 1-59 months [5]. This not only endows pneumonia as a major clinical issue but the one most significant cause of under-five deaths in the nation.

In addition to the catastrophic human cost, in low resource contexts, ARIs have a significant economic cost to households and national health systems. To families already living below or near poverty line, the financial consequences of treating ARI are disastrous. In a recent calculation of Indians, the median direct ARI management cost per child under the age of five was around US 135 in the private medical hospitals and US 54 in the state institutions [6]. Similar research by adjacent nations like Bangladesh and Pakistan indicates the same tendencies: an average price to treat one case of pneumonia is between US13 costs to manage the condition as an outpatient and between US71 and US235 costs to cure the condition as an inpatient. At an alarm rate, the percentage coverage of families who actually spend over half of their total monthly household spending on a single episode of hospitalization stands around 75% [7] . Such statistics explain why ARI is a great financial burden to families who are vulnerable, which is why effective preventive and management interventions that are clinically valid and economically viable are necessary.

To address the burden of ARI in the world, and the country, various international and national systems have laid emphasis on interventions to prevent, diagnose early and manage this illness. Global Action Plan prevention and control of pneumonia (GAPP) focus on the integrated approaches that encompass case management, prevention and treatment of HIV infection, nutrition and breast-feeding behaviors, low birth weight reduction, and control of indoor air pollution [8]. These strategies note that ARI is not only a medical disorder but a multi-factorial societal health issue that is affected by social, environmental, and nutritional determinants. Some of the critical risk factors that contribute to the prevalence and severity of ARIs amongst children include malnutrition, low sanitation standards, poor ventilation, lack of immunization and household air pollution caused by biomass fuel combustion.

These risk factors have been consistently identified and the etiological agents that cause pneumonia and other ARIs have been described as priorities in conducting research. These areas were included among the top ten global research priorities in the Expert Group on Childhood Pneumonia in 2011, in order to help achieve better child health outcomes. Nonetheless, after decades of policy measures and research studies, there are still major gaps in evidence- such as in the epidemiology and etiology of ARI of the Indian context. The limitation of high-quality, community-based data was highlighted as a significant obstacle to the effective development and execution of the preventive measures in one systematic review on pneumonia in India [9].

According to Epidemiological estimates of twelve Indian researches carried out since 1994, it was found out that there are between 2.4 and 7.4 epidemics of ARI among the under-five children per year and per child. These statistics give a general picture of the disease prevalence, but also reveal some serious weaknesses: the vast majority of the available data are obtained in hospitals through studies and therefore will overrepresent the severe cases and may not reflect the overall burden on a community level. Moreover, a lack of research on the etiology and risk factors of the ARI in older children (5-10 years) remains, as it is an age cohort that has been widely overlooked in terms of public health surveillance. Previous hospital-based research on the etiology of pneumonia in India [10] has been useful but limited in the generalizability of their results because they have internal institutional and urban bias.

To fill these evidence gaps, our research project has developed a community-based surveillance system among a cohort group of rural children who are up to the age of ten years. The broad objective of the program is two-fold: to produce effective epidemiological data on the occurrence, spread, and causes of ARI among children, and to establish a platform on which future vaccine trials and population health interventions can be done. This surveillance program aims at expanding the knowledge on the epidemiology of ARI in a broader range of pediatric cases by considering a wider age group that covers children under the age of 5 years and older under the age of 10 years. It is especially important to include this younger group, because infections in children of school age may be relevant to the further transmission of the infection in the community and repeated cycles of infections in the family.

The current paper represents the first-year results of a surveillance program that has been conducted over the last three years of the research. Its objectives include outlining the epidemiological pattern of acute respiratory infections among the study population, investigating the most common clinical and demographic risk factors, and discussing the practices performed in the field of managing the diseases within the community and at the healthcare facilities. Through the combination of epidemiological data and contextual socioeconomic and environmental factors, this research study can be relevant in the growing number of evidence needed to shape child health policy, improve case management plans, and inform future intervention priorities to decrease the burden of ARI on children in India and other low-resource environments.

Methodology

Study Design: This study was a prospective observational cohort study conducted to determine the epidemiological trends, clinical presentation, and management approaches of acute respiratory infections (ARI) in children. Active weekly surveillance and clinical follow-up were implemented to record incidence, severity, and outcomes of ARI among the pediatric population.

Study Area: The study was carried out in the Department of Pediatrics, Sheikh Bhikhari Medical College and Hospital, Hazaribagh, Jharkhand, India.

Study Duration: The study was conducted over a period of one year.

Study Population: The study population comprised children under 10 years of age attending the Department of Pediatrics, either as outpatients or inpatients, presenting with symptoms suggestive of acute respiratory infections.

Sample Size: A total of 300 children were included in the study. The sample size was determined based on hospital admission trends and previous surveillance data indicating the average annual ARI burden in the pediatric population of the hospital's catchment area.

Inclusion Criteria

- Children aged 0–10 years presenting with symptoms of acute respiratory infection (such as cough, nasal discharge, sore throat, ear pain/discharge, or breathing difficulty).
- Children whose parents or guardians provided written informed consent.
- Families who had been residents of the area for at least six months before enrollment.

Exclusion Criteria

- Children with chronic respiratory illnesses such as asthma, cystic fibrosis, or bronchiectasis.
- Children with known congenital heart disease or immunodeficiency.
- Children whose parents refused consent for participation.
- Children with incomplete clinical records or follow-up data.

Data Collection: Structured and pre-tested proformas were used to collect the data which was inputted into a computerized database and analyzed. Each participant was interviewed on detailed demographic, clinical and laboratory data. The clinical history was taken in detail, and physical examination was directed at symptoms and signs of respiratory problems. Presents complaints were cough, sore throat, nasal congestion, earache or discharge and difficulty in breathing. Presence and severity of symptoms were used to classify cases as either Acute Upper Respiratory Infection (AURI) and Acute Lower Respiratory Infection (ALRI) using the Integrated Management of Childhood Illness (IMCI) guidelines.

As indicated, laboratory investigations were conducted. Bacteriological and virological tests of nasal and throat swabs were conducted on a random sample of 5 percent of the AURI cases and all the ALRI cases. Blood was sent to culture and sensitivity and where necessary, urine was sent to screen antigens. The socio-demographic information was also documented like the parental educational status, socioeconomic status and exposure to environmental risk factors such as type of cooking fuel, ventilation, overcrowding, and exposure to tobacco smoke. So, every data was verified to be complete and correct prior to entering the database, and the quality was controlled by the random checking of 10 percent of the case records by senior faculty members.

Procedure: Eligible children were selected on outpatient visits or admission to the hospital. Parents or guardians gave informed consent in writing after the objectives of the study were explained. All enrolled children were thoroughly clinically evaluated by a pediatric resident/trained nurse which included a measurement of vital parameters including respiratory rate, temperature and oxygen saturation with the use of pulse oximeter. Those children with severe symptoms were immediately sent to inpatient treatment and treated in line with National Health Mission (NHM) and IMNCI treatment guidelines. When bacterial infection was suspected antibiotics were given and supportive therapy such as oxygen supplementation and antipyretics were given as required. In order to capture the course of illness and treatment outcomes, all the participants were monitored on a weekly basis, either by paying them a visit in the hospital or talking to them on the phone. Quality and consistency of data were also observed by checking on pediatricians on regular basis to reduce bias and standardize the process.

Statistical Analysis: All the statistical calculations were done in STATA 15.0 (StataCorp, Texas, USA). Analysis was carried out on the data that had been previously cleaned and validated. Demographic, clinical and lab data were presented in the form of descriptive statistics, where the continuous variables were means and standard deviations and categorical variables were frequencies and percentages. ARI and subtypes incidences were determined, based on child-years of observation. The Chi-square test and the Fisher exact test was used to compare categorical variables and Student t-test was used where appropriate where the variables are continuous. In order to determine the independent predictors of severe ARI (ALRI), multivariate logistic regression analysis was conducted by controlling against possible confounders including age, nutritional status, and environmental exposure. The p-value of below 0.05 was taken to be statistically significant."

Result

Table 1 displays the household characteristics of the 300 households enrolled in the project. Almost half (48.3%) of the households owned land, and 22% reported that the head of the household worked in an agriculture-related occupation. Groundwater was the main source of drinking water in 64.7% of households, and only 28.5% had piped water in their household. Access to sanitation was relatively high, with 78% of households using a water-seal latrine. Traditional fuels (wood or cow-dung) were used for cooking by 67.3% of households, and tobacco smoking was reported in 58.7%. Households contained on average 5.84 (±2.33) people, with 1.63 (±1.27) children ≤ 10 years of age, and 1.95 (±0.88) sleeping rooms, which indicated moderate household density and limited space to live in most cases.

Table 1: Household characteristics of enrolled families (N = 300)	
Household characteristics	**Value**
% households with land ownership	48.3
Head of household with agriculture-related occupation (%)	22
Ground water as main source of drinking water (%)	64.7
Piped water in own house (%)	28.5
Access to water-seal latrine (%)	78
Wood/cow-dung as main fuel for cooking (%)	67.3
Tobacco smoker in the household (%)	58.7
Mean (SD) persons per household	5.84 (2.33)
Mean (SD) children ≤10 years per household	1.63 (1.27)
Mean (SD) sleeping rooms per household	1.95 (0.88)

Table 2 presents a summary of the age and gender characteristics of the 300 enrolled children, of whom 160 were boys (53.3%) and 140 were girls (46.7%). At the time of enrollment, 15.3% of participants were less than 1 year old, 43.3% were aged 1–5 years, and 41.4% were aged 5–10 years, with similar age distributions among participants across sex. As it pertains to surveillance lengths, slightly more than half of the total children (56.7%) of the children were surveilled for 48–52 weeks; the remaining participants were monitored for 44–47 weeks (15.3%), 36–43 weeks (13.0%), 28–35 weeks (6.3%), or 27 weeks (8.7%). Overall, the table shows that there is balance with respect to both age and gender and follow-up lengths.

Table 2: Age and gender distribution of enrolled children (N = 300)			
Characteristic	**Boys (n = 160)**	**Girls (n = 140)**	**Total (N = 300)**
Age at enrolment			
< 1 year	24 (15.0%)	22 (15.7%)	46 (15.3%)
1–5 years	70 (43.7%)	60 (42.9%)	130 (43.3%)
5–10 years	66 (41.3%)	58 (41.4%)	124 (41.4%)
Total	**160 (53.3%)**	**140 (46.7%)**	**300 (100%)**
Weeks of surveillance			
Up to 27 weeks	14 (8.7%)	12 (8.6%)	26 (8.7%)
28–35 weeks	10 (6.3%)	9 (6.4%)	19 (6.3%)
36–43 weeks	20 (12.5%)	19 (13.6%)	39 (13.0%)
44–47 weeks	24 (15.0%)	22 (15.7%)	46 (15.3%)
48–52 weeks	92 (57.5%)	78 (55.7%)	170 (56.7%)

In Table 3, the occurrence of respiratory infections is displayed among 300 children under 10 years of age, categorized by age and sex. For infants (below age 1), there was a high incidence for acute respiratory infections (ARI) with boys reporting 6.72 episodes per child-year and girls reporting 6.82 episodes per child-year. However, acute lower respiratory infections (ALRI) were more distinctly reported by boys (0.76) compared to girls (0.35), and ARI-related hospitalizations were only evident for boys (0.11). For both boys (6.66 per child year) and girls (7.36 per child year) aged 1-5 years, ARI incidence remained high, but ALRI rates were at 0.55 and 0.40 respectively and hospitalizations occurred amongst boys more than girls (0.15 vs. 0.04). For children aged 5-10 years, rates of infection were substantially lower than the rates under 5 years age (ARI was at 4.60 in boys and 4.71 in girls; ALRI was at 0.15 and 0.13). Children under 5 years had the highest rates of ARI (boys 6.67 episodes per child-year; girls 7.28 episodes per child year) and ALRI (boys 0.58; girls 0.40). In total, over all ages, boys reported 840 ARI (5.57) and 53 ALRI cases (0.35) compared to girls with 767 ARI (5.91) and 33 ALRI control cases (0.25). The hospitalization notes were infrequent (0.07 compared with 0.02), but boys did show a slightly higher expected estimate burden.

Table 3: Burden of respiratory infections among under-ten children by age and sex (n = 300 children)

Age Group	Weeks of surveillance	Acute Respiratory Infections (ARI)		Acute Lower Respiratory Infections (ALRI)		ARI-related Hospital Admissions	
		Episodes	Incidence	Episodes	Incidence	Episodes	Incidence
	Boys / Girls	Boys / Girls	Boys / Girls	Boys / Girls	Boys / Girls	Boys / Girls	Boys / Girls
< 1 year	480 / 450	62 / 59	6.72 / 6.82	7 / 3	0.76 / 0.35	1 / 0	0.11 / 0.00
29 days – 11 months	–	–	–	–	–	–	–
1–5 years	3 200 / 2 700	410 / 382	6.66 / 7.36	34 / 21	0.55 / 0.40	9 / 2	0.15 / 0.04
5–10 years	4 160 / 3 600	368 / 326	4.60 / 4.71	12 / 9	0.15 / 0.13	0 / 1	0.00 / 0.01
Under 5 years	3 680 / 3 150	472 / 441	**6.67 (6.07–7.27) / 7.28 (6.60–7.96)**	41 / 24	0.58 (0.40–0.76) / 0.40 (0.24–0.55)	10 / 2	0.14 / 0.03
Under 10 years	7 840 / 6 750	840 / 767	**5.57 (5.19–5.95) / 5.91 (5.49–6.33)**	53 / 33	0.35 (0.26–0.45) / 0.25 (0.17–0.34)	10 / 3	0.07 0.02

Discussion

The current research found high burden of acute respiratory infection (ARI) in children less than ten years of age with significantly high rate compared to those less than five years old. The total ARI of 5.57/child-year and 5.91/girls and ALRI of 0.35 and 0.25, respectively, are not far off the results of the past community-based studies in India and other South Asian nations. In rural India, Broor et al. indicated that the incidence of ARIs is 6.0 episode/child-year and ALRI 0.19/child-year indicated that respiratory infections continue to pose a significant major problem in public health in related socio-demographic setting [11]. The slightly greater ARI incidence in the present study could be attributed to environmental risk factors which include biomass fuel consumption (67.3%) and tobacco smoke exposure (58.7%) which are well-established contributors to respiratory morbidity in children (Prajapati et al., 2012) [12]."

Similar patterns were noted in equivalent studies in the urban and semi-urban slum environment, in which poor ventilation, crowding, and poor sanitation were associated with increased respiratory illnesses. As an example, Gladstone et al. (2008) reported common incidences of ARI in infants residing in Indian slums, whose incidences were comparable to our under-five group [13]. Equally, ARI rates of about 6.4 episodes per child-year were reported by Acharya et al. (2003) in South India, highlighting that both environmental exposures and socio-economic deprivation are important factors that determine disease patterns [14]. The household data gathered in our study (almost one-third of the households did not have piped water, more than half of households used biomass fuels) supports these observations and indicates the infrastructural and behavioral determinants continue to be relevant to ARI epidemiology.

The observed incidence of ALRI in our study (0.58 among boys and 0.40 among girls below the age of five years) was in line with previous Indian and regional studies. In South Asia, the incidences of pneumonia were estimated to range at 0.25 to 0.50 episodes per child-year (Rudan et al., 2008), whereas in the whole world, South Asian hospitalization rates of severe ALRI were found to be similar to our hospitalization rates (0.14 to boys, 0.03 to girls) (Nair et al., 2013) [15,16]. These results indicate that, although ARI episodes are frequent, the percentage of these cases going to severe diseases is comparatively low, and it may be associated with more accessible health care or a different change of seeking care at an earlier age. It is in line with the gender difference where boys are a bit more likely to be hospitalized, which is supported by previous research that presupposes that boys more frequently go to hospitals with respiratory diseases (Nair et al., 2013) [16].

As applied to methodological comparisons, our continuous weekly surveillance study offered a more solid estimation of ARI incidence than the studies that used the two-week recall method, which has a high rate of underreporting (Feikin et al., 2010) [17]. Similar arguments were proposed by Lanata et al. (1994) who indicated that the accuracy of the morbidity in recalls is better when there is a shorter length of time due to the practice, which confirms what we have done in our study [18] . Studying of the vast majority of children throughout the period of close to a year also reduced the recollection bias and enabled the data collection to be done seasonally.

But case definition differences and differences in the intensity of surveillance could explain small discrepancies between our results and those of other areas. The high ARI rate could partially be related to a more inclusive definition of clinical significance, encompassing mild upper respiratory infections (URI). As reported by Shapiro (1998) and Selwyn (1990), inconsistencies in the definition of cases can have important effects on the estimates of incidence with a more liberal definition delivering higher rates of ARI [19,20]. However, our ALRI ascertainment was done according to the WHO classification standards, and it was backed by physician checkup minimizing the chances of misclassifying severe cases.

It is likely that the exposure of children to indoor air pollutants was aggravated by the environmental risk factors present in our cohort, particularly, solid fuels became widely used in the population and smoking was very common among our cohort. This is consistent with the results of Sarkar et al. (2013), who also indicated the same relationships between biomass fuel consumption and ARI prevalence within the semi-urban Indian communities [21]. Our study showed an average household size (5.84) and a moderate room density (1.95 sleeping rooms in household) which implies that the households were crowded; this crowding factor corresponded to those of Gladstone et al. (2010) which indicated a strong relationship between crowded households and repeated ARI episodes in early childhood [22].

The decreasing tendency of ARI incidence with age, which may be seen in our data, dropping between more than six episodes per child-year (young children under five years) and about 4.6 in persons aged five years to ten years is, again, also supported by the reduction in susceptibility to respiratory infections as children grow and age. Broor et al. (2007) and Acharya et al. (2003) also mentioned similar tendencies of age in terms of lowering the rate of infection, though with significantly lower rates among older children [11,14]. This trend highlights the importance of placing preventive and management interventions in younger age groups, particularly on infants and preschool-aged children who are the most susceptible to morbidity.

Overall, our findings are comparable to the general epidemiology of ARI in low- and middle-income areas, where environmental exposures, crowding and lack of sanitation continue to be key drivers of disease. The fact that the ARI and ALRI are similar to the incidences reported in previous Indian and international studies enhance the validity of our results. But our a bit higher ARI estimates could reflect on a continuing social health dilemma that is fueled by avoidable household risk factors. The reduction of biomass fuel dependency, smoke free houses and better ventilation and sanitation in households should be given priority in future interventions. Such interventions together with health education at the community level would go a long way in reducing the rate of respiratory diseases in children in such environments.

Conclusion

The case study of acute respiratory infections (ARI) among children indicated that there are considerable epidemiological trends that are influenced by the household, environmental, and demographic factors. The results show that children aged below ten years tend to have high burden of ARI and the highest incidence is among children aged below five years because of their vulnerability through lack of immune system and high contact in the household. Lower respiratory tract infections among younger children are predominant and this indicates the clinical importance of preventive and management strategies at an early stage. The reliance on solid fuels as cooking fuel, pregnancy to domestic tobacco smoke, limited access to piped water and sanitation facilities are also environmental risk factors that are likely to have led to the persistent and recurrence of infections. The study also observed comparable infection trends among boys and girls, suggesting that biological and environmental factors exert a more profound influence than gender. The relatively low rate of hospital admissions, despite frequent ARI episodes, underscores a reliance on community-level or home-based management and possibly underutilization of formal healthcare services. Overall, the results emphasize the need for integrated public health interventions focusing on improved living conditions, enhanced awareness of infection prevention, and strengthened primary healthcare systems to mitigate the burden of respiratory infections among children in resource-limited settings.

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