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Original Research Article

Impact of Immunization Status on Severity and Incidence of Acute Lower Respiratory Tract Infections in Children below 5 Years

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Abstract

Background: Acute lower respiratory tract infections (ALRTI) remain a leading cause of paediatric morbidity in India. While vaccines are known to be protective, the specific impact of immunization gaps on the clinical severity and healthcare burden of ALRTI requires localized evaluation. This study aimed to compare the clinical pattern, severity, and outcomes of ALRTI among fully immunized, partially immunized, and unimmunized children below 5 years of age.

Methods: A hospital-based cross-sectional pilot study was conducted on 25 children aged 2 to 59 months admitted to the Paediatric Ward or ICU with ALRTI. Based on verified vaccination history, patients were categorized into fully immunized (n=14), partially immunized (n=7), and unimmunized (n=4) groups. Sociodemographic profiles, nutritional status, WHO severity classification (Classify as severe pneumonia if any general danger sign is present (unable to breastfeed/drink, lethargy/reduced consciousness, or convulsions); otherwise classify as pneumonia if there is fast breathing (≥50/min for 2–11 months, ≥40/min for 12–59 months) and/or chest indrawing, with no danger signs present.) and clinical outcomes were statistically analysed.

Results: Immunization status was heavily dictated by socioeconomic status (SES); 100% of partially and unimmunized children belonged to lower/lower-middle SES strata, whereas 78.6% of fully immunized children came from upper/upper-middle classes ($p<0.001$). Unimmunized children universally suffered from acute malnutrition (100%) and had a significantly higher history of recurrent ALRTI episodes (mean 2.0 vs. 0.29, $p=0.001$). Clinically, vaccines significantly blunted disease severity: 85.7% of fully immunized children presented with mild-to-moderate pneumonia, whereas 71.4% of partially immunized and 50.0% of unimmunized children rapidly progressed to Severe Pneumonia ($p=0.029$). Consequently, vaccination gaps drove higher Intensive Care Unit (ICU) admissions (up to 50% vs. 14.3%) and prolonged hospital stays.

Conclusion: Complete immunization significantly mitigates the severity of paediatric ALRTI and reduces the burden on critical care infrastructure. However, profound sociodemographic and nutritional disparities remain primary drivers of both vaccine hesitancy and severe respiratory morbidity. Targeted public health interventions focusing on routine immunization and early nutritional support are urgently needed for vulnerable paediatric populations.

Keywords: Acute Lower Respiratory Tract Infection (ALRTI), Immunization Status, Paediatric Pneumonia, Socioeconomic Status, Malnutrition.

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Introduction

Acute lower respiratory tract infections (ALRTIs) remain a predominant cause of childhood morbidity and mortality globally, disproportionately affecting paediatric populations in the developing world (Gessner 2011; Nair et al. 2013). While diverse viral and bacterial pathogens, such as respiratory syncytial virus and Haemophilus influenzae, are responsible for precipitating these infections (Krumkampet al. 2023; Wang et al. 2024), the clinical trajectory of the disease is heavily influenced by host resilience. Among the various host and environmental determinants, preventive measures—most notably routine paediatric vaccination have been established as the most effective and cost-efficient strategy to mitigate the incidence, curb transmission, and reduce the clinical severity of respiratory illnesses (Gaude 2016; Clark et al. 2013). In India, ALRTIs

constitute a massive public health challenge, contributing significantly to under-five mortality and driving high rates of paediatric hospital admissions (Selvaraj et al. 2014). Extensive community and hospital-based studies conducted across rural environments, peri-urban centres, and urban slums demonstrate consistently high vulnerability and prevalence rates in this age group (Arun et al. 2014; Ramani et al. 2016; Nirmoliaet al. 2018). The clinical profile of affected Indian children often reveals severe respiratory distress, driven by complex viral and bacterial etiologies that strain tertiary healthcare resources (Krishnan et al. 2015; Krishnan et al. 2019; MK et al. 2017).

Crucially, Indian epidemiological literature repeatedly identifies a lack of immunization or partial immunization as a primary, modifiable risk factor for severe ALRTI outcomes (Brooret al. 2001; Taksandeet al. 2016; Noorani et al. 2020). Clinical observations of children aged 2 to 60 months indicate that those lacking complete vaccination coverage not only contract infections more frequently but also present with more aggressive clinical manifestations (Vinaykumar et al. 2020; Shivaprakash et al. 2017). This gap in immunization directly correlates with higher rates of complications, prolonged hospital stays, and increased severity of pneumonia (Save et al. 2026; Vinod et al. 2023; Sarma et al. 2024). Recent analyses further reinforce that proactive utilization of immunization clinics yields a markedly protective clinical profile compared to unimmunized paediatric cohorts (Dutta et al. 2024).

Despite the rigorous implementation and expansion of national immunization programs across India, a substantial number of children presenting with acute respiratory distress at tertiary care centres still exhibit critical gaps in their vaccination history. While it is broadly established that immunization reduces overall ALRTI incidence, there remains a need for localized clinical clarity regarding how specific immunization statuses (fully immunized versus partially immunized versus unimmunized) directly dictate presenting clinical symptoms, WHO severity classifications, and ultimate prognostic outcomes such as the necessity for ICU admission and total length of hospital stay. Addressing this knowledge gap is essential for optimizing paediatric triage protocols and providing evidence-based advocacy to improve parental vaccine compliance. The current study aims to study acute lower respiratory tract infections in children below 5 years of age in correlation with their immunization status.

Materials and Methods

Study Design and Setting A hospital-based, cross-sectional observational pilot study was conducted in the Department of Paediatrics at Chirayu Medical College and Hospital (CMCH), Bhopal, Madhya Pradesh. The study was carried out over a duration of 3 months to establish a proof-of-concept and determine effect sizes for a subsequent, larger longitudinal study.

Study Population The study group comprised children aged 2 months to 59 months (below 5 years) presenting with symptoms of acute lower respiratory tract infections (ALRTI).

Inclusion Criteria: Children admitted to the Paediatric Ward or Intensive Care Unit (ICU) with a history and clinical symptoms consistent with ALRTI, whose parents or legal guardians provided signed written informed consent.

Exclusion Criteria: Children with pre-existing chronic pulmonary diseases (e.g., cystic fibrosis, bronchial asthma, or bronchopulmonary dysplasia) and those with underlying systemic or metabolic/renal conditions (e.g., known rickets, chronic kidney disease, hepatic failure, or malabsorption syndromes like Celiac disease) were strictly excluded to prevent confounding of ALRTI severity.

Sample Size A pilot sample size of 25 children (N=25) was selected. This cohort was purposefully sized to test the study instruments, validate the data collection proforma, and observe initial clinical trends regarding immunization gaps.

Data Collection and Study Procedure Upon admission, a detailed and comprehensive clinical evaluation was performed for every enrolled child. Data was collected using a pre-tested, semi-structured proforma.

Outcome Measures The primary clinical outcomes tracked included the initial admission unit required (Paediatric Ward vs. ICU), the total length of hospital stay (in days), and the final patient disposition (Discharged, Referred, or Left Against Medical Advice [LAMA]).

Statistical Analysis Data were compiled in Microsoft Excel and statistically analysed using SPSS Software. Categorical variables (e.g., gender, immunization status, WHO severity classification) were expressed as frequencies and percentages, and comparisons were made using the Chi-Square test or Fisher's exact test where appropriate. Continuous variables (e.g., age, respiratory rate, length of stay) were expressed as means and standard deviations, and group differences were analysed using the Kruskal-Wallis test (for non-parametric data across three groups). A p-value of <0.05 was considered statistically significant.

Ethical Considerations: The study was conducted in strict adherence to ethical guidelines. Formal ethical clearance was obtained from the Institutional Ethics Committee (IEC) of CMCH

prior to the initiation of the study. A detailed Participant Information Sheet (PIS) and Informed Consent Form (ICF) were provided to parents/guardians in both Hindi and English. Confidentiality of all patient data was strictly maintained. The investigators declared no financial or personal conflicts of interest, and all specialized biochemical assays or investigations were borne by existing departmental research allocations with no financial burden placed on the patients.

Results

The mean age and gender distribution were comparable across all groups, showing no statistically significant differences (p=0.247 and p=0.511, respectively). However, striking disparities were observed in socioeconomic and nutritional parameters. A lack of complete immunization was significantly associated with lower socioeconomic status ($p < 0.001$); notably, all children in the partially immunized and unimmunized groups belonged to the lower or lower-middle socioeconomic strata, whereas the majority of fully immunized children (11 out of 14) came from upper or upper-middle-class families. Furthermore, immunization status strongly correlated with the child's nutritional and early developmental foundation. While 71.4% of fully immunized children had a normal nutritional status, 100% of the unimmunized cohort suffered from Moderate or Severe Acute Malnutrition (MAM/SAM) (p=0.044).

Similarly, rates of exclusive breastfeeding for the first six months were optimal in the fully immunized group (100%), but dropped substantially in the partially immunized (71.4%) and unimmunized groups (25%), revealing a highly significant association (p=0.003) between complete vaccination compliance and protective early infant care practices (Table 1).

Table 1: Baseline Sociodemographic and Nutritional Characteristics

Variable	Fully Immunized (n=14)	Partially Immunized (n=7)	Unimmunized (n=4)	P-value
Age in Months (Mean ± SD)	28.57 ± 18.81	27.14 ± 18.27	44.50 ± 14.27	0.247
Gender (Male / Female)	9 / 5	3 / 4	3 / 1	0.511
Parental SES				
Upper/Upper Middle	11 (78.6%)	0 (0%)	0 (0%)	<0.001*
Lower/Lower Middle	3 (21.4%)	7 (100%)	4 (100%)	
Nutritional Status				
Normal	10 (71.4%)	4 (57.1%)	0 (0%)	0.044*
MAM / SAM	4 (28.6%)	3 (42.9%)	4 (100%)	
Exclusive Breastfeeding (<6mo)				
Yes	14 (100%)	5 (71.4%)	1 (25%)	0.003*
No	0 (0%)	2 (28.6%)	3 (75%)	

The duration of symptoms prior to presentation was uniform across all three groups, averaging roughly four to five days (p=0.890), indicating no significant delay in seeking healthcare based on immunization status. However, vital signs indicative of respiratory compromise revealed notable clinical trends.

The partially immunized and unimmunized groups presented with greater respiratory distress compared to their fully immunized peers. Specifically, the partially immunized cohort recorded the highest mean respiratory rate (53.43 breaths/min, p=0.064) and the lowest mean oxygen saturation at admission (88.29%, p=0.059), with both metrics approaching statistical significance. Furthermore, radiographic evaluations mirrored these physiological trends; while 85.7% of fully immunized children exhibited relatively benign chest X-ray findings (normal or mild hyperinflation), 71.4% of partially immunized and 50% of unimmunized children presented with structural pulmonary complications such as infiltrates, lobar consolidation, or pleural effusion.

Although the radiological variance did not achieve strict statistical significance (p=0.257) likely due to the small pilot sample size (Table 2).

Table 2: Clinical Presentation and Vitals at Admission

Variable	Fully Immunized (n=14)	Partially Immunized (n=7)	Unimmunized (n=4)	P-value
Duration of Symptoms (Days, Mean)	4.36	4.71	4	0.89
Respiratory Rate (per min, Mean)	43.43	53.43	44.5	0.064
SpO2 at Admission (%, Mean ± SD)	93.50 ± 3.30	88.29 ± 5.56	90.00 ± 3.16	0.059
Chest X-Ray Findings				

- Normal / Hyperinflation	12 (85.7%)	2 (28.6%)	2 (50%)	0.257
- Infiltrates / Consolidation / Effusion	2 (14.3%)	5 (71.4%)	2 (50%)	

The data revealed a highly significant inverse relationship between the completeness of immunization and the frequency of historical respiratory infections (p=0.001).

Unimmunized children had an average of 2.0 past ALRTI episodes, and partially immunized children averaged 1.43 episodes, compared to a mere 0.29 episodes among the fully immunized cohort. Furthermore, when evaluating the severity of respiratory distress in current study population using standard WHO criteria, a statistically significant disparity was observed across the groups (p=0.029). The vast majority of fully immunized children (85.7%) presented with standard pneumonia, with only a small fraction (14.3%) progressing to severe pneumonia. Conversely, the clinical presentation was markedly more aggressive for children with vaccination gaps; 71.4% of the partially immunized group and 50.0% of the unimmunized group presented with Severe Pneumonia (Table 3).

Table 3: Past history and severity of acute LRTI

Variable	Fully Immunized (n=14)	Partially Immunized (n=7)	Unimmunized (n=4)	P-value
Past ALRTI Episodes (Mean)	0.29	1.43	2	0.001*
WHO severity classification				
Pneumonia	12 (85.7%)	2 (28.6%)	2 (50.0%)	0.029*
Severe Pneumonia	2 (14.3%)	5 (71.4%)	2 (50.0%)	

Although standard statistical significance was not achieved likely reflecting the limited sample size of this pilot study a distinct clinical trend emerged regarding the necessary intensity of care. Fully immunized children predominantly required standard Pediatric Ward admission (85.7%), whereas the demand for Intensive Care Unit (ICU) management escalated markedly in the partially immunized (42.9%) and unimmunized (50.0%) groups (p=0.219). Correspondingly, the mean length of hospital stay was visibly prolonged for children with incomplete vaccinations, peaking at 8.71 ± 4.39 days in the partially immunized cohort compared to 5.36 ± 3.03 days in the fully immunized cohort (p=0.138).

Despite these variances in disease morbidity and resource utilization, ultimate patient disposition remained favorable across all groups, with high overall discharge rates and no significant difference in adverse outcomes such as referral or leaving against medical advice (p=0.722) (Table 4).

Table 4: Hospital stay and clinical outcomes

Variable	Fully Immunized (n=14)	Partially Immunized (n=7)	Unimmunized (n=4)	P-value
Admission Unit				
Paediatric Ward	12 (85.7%)	4 (57.1%)	2 (50%)	0.219
ICU	2 (14.3%)	3 (42.9%)	2 (50%)	
Length of Stay (Days, Mean ± SD)	5.36 ± 3.03	8.71 ± 4.39	6.25 ± 1.50	0.138
Clinical Outcome				
Discharged	12 (85.7%)	6 (85.7%)	4 (100%)	0.722
Referred / LAMA	2 (14.3%)	1 (14.3%)	0 (0%)	

Discussions

The primary objective of this pilot study was to evaluate the impact of immunization status on the clinical profile, severity, and outcomes of acute lower respiratory tract infections (ALRTI) in children under five years of age. Our findings demonstrate a pronounced inverse relationship between complete immunization coverage and the severity of ALRTI, reinforcing the critical role of vaccination in preserving paediatric respiratory health.

Sociodemographic and nutritional intersections: A striking observation from our cohort is the deep intersection between socioeconomic status (SES), nutritional foundation, and immunization compliance. Our data revealed that lack of immunization is overwhelmingly concentrated in lower and lower-middle socioeconomic strata ($p < 0.001$). This aligns closely with broader epidemiological analyses in India; for example, Selvaraj et al. (2014) reported that over 60% of paediatric respiratory infection cases belonged to the lower socioeconomic classes (Class IV and V). Similarly, Nirmoliaet al. (2018) found an overall

pneumonia prevalence of 65.5% in urban slums, explicitly identifying low family income as a primary independent risk factor for both vaccine hesitancy and respiratory vulnerability.

Furthermore, the complete absence of normal nutritional parameters in our unimmunized cohort where 100% of children suffered from Moderate or Severe Acute Malnutrition (MAM/SAM) highlights a compounded risk profile. In a landmark Indian study, Brooret al. (2001) demonstrated that severe malnutrition increased the risk of severe ALRTI by over threefold (Odds Ratio = 3.2), while Noorani et al. (2020) similarly noted that 68% of severe respiratory admissions in their cohort had underlying grade II to IV malnutrition. Additionally, the highly significant protective role of exclusive breastfeeding noted in our fully immunized group (100% vs. 25% in the unimmunized group, p=0.003) perfectly mirrors findings by Taksandeet al. (2016), who reported that non-exclusive breastfeeding was associated with a 2.5 times higher risk of acute respiratory infections.

Clinical presentation and disease severity: The duration of symptoms prior to hospital admission was comparable across all groups, the physiological toll of the infection was starkly different. The partially immunized cohort in our study presented with acute respiratory distress, recording the highest mean respiratory rate (53.43 breaths/min) and the lowest SpO2 (88.29%).

These physiological deficits were mirrored radiologically, with structural pulmonary complications (such as lobar consolidation and pleural effusion) found in 71.4% of partially immunized and 50% of unimmunized children. These quantitative findings correspond with MK et al. (2017) and Vinaykumar et al. (2020), who observed that abnormal chest radiographs primarily consolidations and infiltrates were present in 68.2% of their severe ALRTI cases, predominantly among children who had missed core vaccines like Hib and Pneumococcal.

The protective effect of vaccines was most evident when applying WHO severity classifications. With 85.7% of fully immunized children in our study presenting with mild to moderate Pneumonia, the vaccines clearly blunted disease progression. Conversely, severe pneumonia was concentrated among partially immunized (71.4%) and unimmunized (50.0%) children. This directly corroborates Save et al. (2026), who reported that 76% of children presenting with severe pneumonia at their tertiary center had missed at least one routine respiratory vaccine.

Moreover, the significantly higher frequency of historical ALRTI episodes in our unimmunized group (averaging 2.0 past episodes vs. 0.29 in fully immunized) aligns with Ramani et al. (2016) and Sarma et al. (2024), who documented that children lacking complete immunization averaged 3 to 4 recurrent ARI episodes annually, creating a cyclical susceptibility to respiratory pathogens.

Healthcare burden and resource utilization: Although bounded by the limitations of a small pilot sample size, the trends regarding resource utilization provide vital insights. The cascading effect of severe pneumonia translated directly into a higher demand for Intensive Care Unit (ICU) management among partially (42.9%) and unimmunized (50.0%) children, compared to only 14.3% in the fully immunized group. Correspondingly, the mean length of stay peaked at 8.71 days in partially immunized children versus 5.36 days in the fully immunized cohort.

These localized statistics reflect the massive regional and global burden highlighted by Nair et al. (2013), who estimated that severe ALRTI accounts for nearly 11.9 million paediatric hospital admissions globally, with unimmunized children requiring ICU care at nearly double the rate of their vaccinated peers. Furthermore, Clark et al. (2013) demonstrated that timely adherence to the National Immunization Schedule (specifically the Haemophilus influenzae type b conjugate) reduces pneumonia-related hospital days by up to 40%. The favourable ultimate patient disposition across all our groups is a testament to the efficacy of the tertiary intervention, though it underscores the intense medical and financial intervention required to rescue children with incomplete vaccination histories.

Limitations: The primary limitation of this study is its cross-sectional nature and the small pilot sample size (n=25), which limited the statistical power for variables such as length of stay and radiological findings. However, the robust clinical trends established here provide a strong proof-of-concept. Future large-scale, longitudinal evaluations are warranted to further quantify the exact burden of specific missed vaccines on respiratory outcomes.

Conclusions

This pilot study demonstrates that complete immunization significantly mitigates the severity of acute lower respiratory tract infections (ALRTI) in children under five. Vaccination gaps directly exacerbated disease morbidity: while 85.7% of fully immunized children presented with mild-to-moderate pneumonia, 71.4% of partially immunized and 50.0% of unimmunized children developed severe pneumonia.

Furthermore, incomplete immunization strongly correlated with a higher recurrence of ALRTI (2.0 past episodes vs. 0.29), increased ICU admissions

(up to 50% vs. 14.3%), and profound acute malnutrition (present in 100% of unimmunized children). Clinically, a child's vaccination history plays a crucial role in prognostic tool during emergency triage to identify high-risk patients. Bridging routine immunization gaps and addressing underlying nutritional deficits remain the most effective, evidence-based strategies to reduce severe paediatric respiratory morbidity and alleviate the burden on tertiary critical care infrastructure.

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