

# Comparison of Pattern of Lower Respiratory Tract Infection in Children below 12 Years of Age with their Immunisation Status

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Received: 26<sup>th</sup> Feb, 2026; Revised: 7<sup>th</sup> March 2026; Accepted: 12<sup>th</sup> April, 2026; Available Online: 20<sup>th</sup> April, 2026

## ABSTRACT

**Background:** The lower respiratory tract infection (LRTI) is one of the most relevant causes of childhood morbidity as well as mortality in the developing countries, and immunisation status is seen as the crucial determinant of disease burden in these regions.

**Objective:** To evaluate and compare female-male pattern, severity, and frequency of LRTIs of children under 12 years old in relation to their immunisation status and to begin to define the sociodemographic risk factors.

**Methods:** The investigation was a cross-sectional study that was carried out depending on a hospital over 6 months in the Department of Pediatrics in Shri Sathya Sai Medical College, Chengalpattu, Tamil Nadu, among 170 children with confirmed LRTI. The status of immunisation was defined as fully, partially or not immunised. The Chi-square test was utilized for comparing pattern, severity and frequency of LRTI between groups.

**Results:** The most prevalent pattern of LRTI was bronchopneumonia (40.0%), which was much more common among non-immunised children (59.3%), than among those who are fully immunised (34.1%),  $p=0.012$ . The severity of the disease was significantly higher in non-immunised children (37.1%) compared to fully immunised children (7.3%) ( $p=0.001$ ). Very frequent incidences of LRTI (ranged at or above 4/year) were strongly greater in non-immunised kids (25.9%) than completely inoculated (3.7%) ( $p<0.001$ ). Malnutrition, overcrowding and illiteracy of parents were significantly linked to partial or lack of immunisation ( $p<0.05$ ).

**Conclusion:** Complete immunisation is significantly associated with milder, less frequent, and less severe LRTIs in children. Strengthening routine immunisation coverage, alongside addressing nutritional and environmental risk factors, is essential to lower the LRTI burden in this population.

**Keywords:** Lower respiratory tract infection, Immunisation status, Pneumonia, Bronchopneumonia, Children, Chengalpattu

**How to cite this article:** Praneeth M, Prasad KR, Suresh P. Comparison of Pattern of Lower Respiratory Tract Infection in Children below 12 Years of Age with their Immunisation Status. Int J Drug Deliv Technol. 2026;16(34s):38-44. DOI: 10.25258/ijddt.16.34s.5

**Source of support:** Nil.

**Conflict of interest:** None

## 1. INTRODUCTION

The LRTIs are regarded as one of the greatest threats to the health of a population especially among the lower as well as middle-income nations. India, the South-East Asia Region (India, Indonesia, Bangladesh and Nepal) as a whole is the largest contributor to globalization of the disease having had about 43 million new cases of LRTI

outbreaks per year out of an estimated 156 million cases due to the disease on children worldwide at the moment, indicating the proportionate amount of the disease burden it carries.<sup>1,2</sup>

Of the acute respiratory infections (ARIs) of which LRTIs are the most severe end, 20-30 percent of child deaths below five years old are caused. The death of children due to ARIs in this age group is about 47 percent of overall

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child mortality in the country including deaths due to tuberculosis, influenza and bronchiolitis.<sup>3</sup> Although this is largely avoidable, there is alarming high prevalence of child deaths due to LRTI, mainly because the preventive modalities such as immunization, nutritional supplementation and indoor air pollution reduction have not reached universal coverage.

LRTIs epidemiology in children is complex because of interaction of host, environmental, and sociodemographic risk factors. The course of most LRTIs is more severe in male children than females, resulting in higher rates of LRTI-related deaths in males, particularly in community-acquired pneumonia.<sup>5</sup> Well-documented modifiable risk factors for LRTI in the paediatric population include parental illiteracy, low socioeconomic status, household overcrowding, use of biomass or kerosene fuel indoors, poor ventilation, anaemia, and malnutrition — all of which compound the vulnerability of incompletely immunised children.<sup>6</sup>

Immunisation stands out as the most cost-effective, scalable, and evidence-based intervention for reducing LRTI mortality as well as morbidity in kids.

Vaccines targeting *Haemophilus influenzae* type b (Hib), *Streptococcus pneumoniae*, influenza, as well as measles directly address the leading causative agents of severe LRTI in the paediatric age group. Measles vaccination supplemented by a second-opportunity dose has been shown to significantly reduce childhood pneumonia and its mortality.<sup>4</sup> Studies from Tamil Nadu and other Indian states have further demonstrated that kids from rural areas as well as lower socioeconomic strata are disproportionately underimmunised, making them at higher risk of severe and recurrent LRTI episodes.<sup>7</sup>

While several studies have examined epidemiology as well as risk factors linked with LRTI in Indian children, comparative data linking the specific pattern, severity, and frequency of LRTIs with the child's immunisation status remain limited in the Chengalpattu District context. Srinivasa and Patel<sup>8</sup> documented bronchopneumonia as the predominant LRTI pattern in under-five children in a tertiary centre setting; however, the influence of immunisation status on disease pattern and outcomes was not systematically assessed. Moharkar and Aglave<sup>1</sup> provided evidence that immunisation status significantly modifies LRTI pattern and clinical course, yet region-specific data from Tamil Nadu are lacking. The present study was therefore designed to fill this knowledge gap by systematically comparing the pattern, severity, and frequency of LRTIs in kids below 12 years of age according to their immunisation status in a South Indian tertiary paediatric setting.

## 2. MATERIALS AND METHODS

### 2.1 Study Design and Setting

A hospital-based, cross-sectional observational investigation was led in the Department of Pediatrics, Shri Sathya Sai Medical College and Research Institute, Ammapettai, Chengalpattu District, Tamil Nadu, India over a period of 6 months (March 2025 – August 2025). The institution serves a mixed urban–rural catchment population in Chengalpattu District and provides a representative cross-section of paediatric LRTI presentations in the region.

### 2.2 Sample Size and Sampling

Sample size was calculated utilizing formula  $n = 4pq/L^2$ , where  $p = 54.9\%$  (prevalence of LRTI in immunised children derived from a prior study<sup>1</sup>),  $q = 45.1\%$ , and  $L = 8\%$  (precision error). This yielded  $n = 154.75$ , which was inflated by a 10% non-response rate to give a final sample size of 170. Participants were enrolled by consecutive sampling of all eligible kids admitted with LRTI during study period until target was accomplished.

### 2.3 Inclusion and Exclusion Criteria

**Inclusion criteria:** All kids below 12 years of age presenting with clinical features of LRTI — including bronchitis, bronchiolitis, pneumonia, bronchopneumonia, or bronchiectasis — admitted to or attending the Paediatrics Department during the study period.

**Exclusion criteria:** Children with URTI; non-infectious lower respiratory conditions (bronchial asthma, gastro-oesophageal reflux disease, foreign body aspiration, aspiration pneumonia); immunocompromised children (congenital immunodeficiency, HIV, or on immunosuppressive therapy); and those whose guardians refused participation.

### 2.4 Data Collection

A pretested structured proforma was utilized to record sociodemographic information, clinical history, presenting symptoms, duration of illness, past and family history, nutritional status (weight, height, anaemia, malnutrition graded by WHO criteria), living conditions (overcrowding, indoor pollution, ventilation), immunisation history, clinical diagnosis, and radiological findings. Diagnosis was confirmed by clinical examination corroborated with chest X-ray and relevant investigations including complete blood count, ESR, CRP, blood culture, and Mantoux test as clinically indicated.

Immunisation status was categorised as: (1) Fully immunised — all vaccines received as per the Indian Academy of Pediatrics (IAP) recommended immunisation schedule<sup>12</sup> for the child's age; (2) Partially immunised — one or more age-appropriate vaccines missed; and (3) Not immunised — no vaccines administered. LRTI pattern was classified into bronchopneumonia, acute bronchiolitis, pneumonia, bronchitis, and bronchiectasis. Severity was

graded as mild, moderate, or severe based on WHO-IMCI criteria.<sup>10</sup> Frequency of LRTI episodes was categorised as: very frequent ( $\geq 4$  episodes/year), frequent (3 episodes/year), less frequent (2 episodes/year), and rare (1 episode/year).

**2.5 Statistical Analysis**

Data were entered into Microsoft Excel 2019 and evaluated utilizing SPSS version 17.0 (IBM Corp., Armonk, NY). Descriptive statistics were expressed as percentages and frequencies. Chi-square test was done to examine associations amid immunisation status and categorical outcome variables (LRTI pattern, severity, frequency, and risk factors). A p-value of  $<0.05$  was deemed statistically substantial.

**2.6 Ethical Considerations**

Institutional Ethics Committee of Shri Sathya Sai Medical College and Research Institute approved this research. Informed consent was signed in written form by a

parent/legal guardian of all the enrolled children. It was participation on a voluntary basis and also all data were highly confidential.

**3. RESULTS**

**3.1 Socio-demographic Profile**

There were 170 confirmed LRTI children who were enrolled. Table 1 shows the socio-demographic profile. Largest age group was 3–6 years (30.6%), trailed by 1–3 years (28.2%). Male children predominated, comprising 57.6% of the sample — a finding consistent with the established sex-based differential in LRTI susceptibility.<sup>5</sup> A majority of participants (50.6%) belonged to the lower socioeconomic class (Kuppuswamy Classes IV–V), and 46.5% resided in rural areas. Regarding nutritional status, only 43.5% of children were well-nourished, while 28.8% had mild malnutrition, 18.8% moderate malnutrition, and 8.9% severe malnutrition — underscoring the significant nutritional vulnerability of study population.

**Table 1:** Socio-demographic Profile of Study Participants (n=170)

Characteristic	Category	Frequency (n)	Percentage (%)
Age Group	0–1 year	34	20.0
	1–3 years	48	28.2
	3–6 years	52	30.6
	6–12 years	36	21.2
Gender	Male	98	57.6
	Female	72	42.4
Socioeconomic Status	Upper (Class I–II)	21	12.4
	Middle (Class III)	63	37.0
	Lower (Class IV–V)	86	50.6
Residence	Urban	91	53.5
	Rural	79	46.5
Nutritional Status	Well-nourished	74	43.5
	Mild malnutrition	49	28.8
	Moderate malnutrition	32	18.8
	Severe malnutrition	15	8.9

**3.2 Immunisation Status**

Table 2 presents the immunisation status distribution. Less than half of the enrolled children (48.2%) were fully immunised. Partial immunisation was found in 35.9% and 15.9% were not immunised at all. Non-immunised children were notably younger (mean age  $21.8 \pm 18.7$

months) compared to fully immunised ( $51.4 \pm 28.6$  months) and partially immunised ( $38.2 \pm 22.3$  months) children, reflecting the inverse relationship between age and immunisation completeness — with younger infants having missed scheduled doses due to delayed health-seeking behaviour or disrupted immunisation services.

**Table 2:** Distribution of Immunisation Status Among Study Participants (n=170)

Immunisation Status	Frequency (n)	Percentage (%)	Mean Age (months) ± SD
Fully Immunised	82	48.2	51.4 ± 28.6
Partially Immunised	61	35.9	38.2 ± 22.3
Not Immunised	27	15.9	21.8 ± 18.7
Total	170	100.0	41.6 ± 25.8

**3.3 Pattern of LRTI According to Immunisation Status**

The distribution of LRTI patterns across immunisation groups is shown in Table 3. Bronchopneumonia was the most prevalent LRTI diagnosis overall (40.0%), followed by acute bronchiolitis (25.3%), pneumonia (20.6%), bronchitis (12.4%), and bronchiectasis (1.8%). Among non-immunised children, bronchopneumonia constituted nearly three-fifths (59.3%) of all LRTI presentations,

compared to 39.3% in the partially immunised group and 34.1% in the fully immunised group. Acute bronchiolitis was more common in fully (26.8%) and partially immunised (27.9%) groups compared to non-immunised children (14.8%). The correlation amongst LRTI pattern and immunisation status was statistically substantial ( $\chi^2 = 12.84$ ,  $df = 8$ ,  $p = 0.012$ ). It shows that point of immunisation has a significant influence on the clinical phenotype of LRTI in this childhood demographic.

**Table 3:** Pattern of LRTI According to Immunisation Status (n=170)

LRTI Pattern	Fully Immunised n (%)	Partially Immunised n (%)	Not Immunised n (%)	Total n (%)
Bronchopneumonia	28 (34.1)	24 (39.3)	16 (59.3)	68 (40.0)
Acute Bronchiolitis	22 (26.8)	17 (27.9)	4 (14.8)	43 (25.3)
Pneumonia	18 (22.0)	12 (19.7)	5 (18.5)	35 (20.6)
Bronchitis	12 (14.6)	7 (11.5)	2 (7.4)	21 (12.4)
Bronchiectasis	2 (2.4)	1 (1.6)	0 (0.0)	3 (1.8)
Total	82 (100)	61 (100)	27 (100)	170 (100)
Chi-square = 12.84, df = 8, p = 0.012*				

**3.4 Severity of LRTI According to Immunisation Status**

Table 4 shows the severity stratified by immunisation. Among fully immunised children, the majority (62.2%) had mild LRTI, whereas severe disease was observed in only 7.3%. In stark contrast, severe LRTI was recorded in 37.1% of non-immunised children and 18.0% of the

partially immunised group. Mild disease was substantially less frequent in non-immunised (18.5%) compared to fully immunised (62.2%) children. The association between severity and immunisation status was highly significant ( $\chi^2 = 28.61$ ,  $df = 4$ ,  $p < 0.001$ ), confirming that full immunisation confers a strong protective effect against severe LRTI presentations.

**Table 4:** Severity of LRTI According to Immunisation Status (n=170)

Severity	Fully Immunised n (%)	Partially Immunised n (%)	Not Immunised n (%)	Total n (%)
Mild	51 (62.2)	23 (37.7)	5 (18.5)	79 (46.5)
Moderate	25 (30.5)	27 (44.3)	12 (44.4)	64 (37.6)
Severe	6 (7.3)	11 (18.0)	10 (37.1)	27 (15.9)
Total	82 (100)	61 (100)	27 (100)	170 (100)
Chi-square = 28.61, df = 4, p < 0.001*				

### 3.5 Frequency of LRTI Episodes According to Immunisation Status

Recurrent LRTI episodes — a reflection of the child's cumulative susceptibility — were strongly associated with immunisation status (Table 5). Among fully immunised children, the majority (46.3%) had only rare episodes (once per year), while very frequent episodes ( $\geq 4$  per year) were uncommon (3.7%). Among non-immunised children,

37.0% had frequent episodes (3 per year) and 25.9% had very frequent episodes ( $\geq 4$  per year), compared to only 14.6% and 3.7% respectively in the fully immunised group. This inverse gradient in episode frequency across immunisation categories was highly statistically substantial ( $\chi^2 = 31.47$ ,  $df = 6$ ,  $p < 0.001$ ), affirming that immunisation substantially reduces both the frequency of LRTI occurrence and the likelihood of recurrent disease.

**Table 5:** Frequency of LRTI Episodes According to Immunisation Status (n=170)

Frequency of Episodes	Fully Immunised n (%)	Partially Immunised n (%)	Not Immunised n (%)	Total n (%)
Rare (1 episode/year)	38 (46.3)	14 (23.0)	3 (11.1)	55 (32.4)
Less Frequent (2 episodes/yr)	29 (35.4)	24 (39.3)	7 (25.9)	60 (35.3)
Frequent (3 episodes/yr)	12 (14.6)	17 (27.9)	10 (37.0)	39 (22.9)
Very Frequent ( $\geq 4$ episodes/yr)	3 (3.7)	6 (9.8)	7 (25.9)	16 (9.4)
Total	82 (100)	61 (100)	27 (100)	170 (100)
Chi-square = 31.47, df = 6, p < 0.001*				

### 3.6 Association of Risk Factors with Immunisation Status

Table 6 presents the distribution of environmental and sociodemographic risk factors across immunisation categories. Overcrowding (63.0%), kerosene lamp use (44.4%), poor ventilation (51.9%), malnutrition (63.0%), anaemia (48.1%), parental illiteracy (59.3%), and low socioeconomic status (63.0%) were significantly more

prevalent among non-immunised children compared to their fully immunised counterparts (all  $p < 0.05$ ). The findings suggest that sociodemographic vulnerabilities leading to incomplete immunisation predisposition in the children are also an independent risk factor in LRTI, which causes a compounding effect. It is noteworthy that malnutrition and illiteracy of parents exhibited the most statistically significant associations ( $p < 0.001$ ), which makes them focus areas of combined interventions.

**Table 6:** Association of Risk Factors with Immunisation Status and LRTI Occurrence (n=170)

Risk Factor	Fully Immunised n=82 (%)	Partially Immunised n=61 (%)	Not Immunised n=27 (%)	p-value
Overcrowding	29 (35.4)	31 (50.8)	17 (63.0)	0.018*
Kerosene lamp use	11 (13.4)	16 (26.2)	12 (44.4)	0.002*
Poor ventilation	22 (26.8)	27 (44.3)	14 (51.9)	0.008*
Malnutrition	24 (29.3)	35 (57.4)	17 (63.0)	<0.001*
Anaemia	18 (22.0)	24 (39.3)	13 (48.1)	0.006*
Parental illiteracy	14 (17.1)	22 (36.1)	16 (59.3)	<0.001*
Low socioeconomic status	31 (37.8)	38 (62.3)	17 (63.0)	0.003*

## 4. DISCUSSION

A cross sectional study comparing the immunisation status in 170 children below 12 years of age with pattern, severity and frequency of LRTI among kids in a tertiary paediatric unit at the Tamil Nadu, Chengalpattu district was used to systematically analyse the association of immunisation status with LRTI. Findings consistently demonstrate that complete immunisation is associated with significantly milder, less frequent, and less severely manifesting LRTIs — providing robust local evidence for the protective role of immunisation in shaping paediatric LRTI outcomes.

The overall immunisation coverage in our study — with only 48.2% of enrolled children fully immunised — is a matter of serious concern. This is broadly consistent with results of Moharkar and Aglave<sup>1</sup> (54.9% fully immunised in a similar hospital-based sample) and the district-level data reported by Savitha and Gopalakrishnan<sup>7</sup> from rural Tamil Nadu, where incomplete immunisation was strongly linked to low parental education and socioeconomic disadvantage. The 15.9% non-immunisation rate in our study is particularly alarming given that all five vaccines included in the WHO-recommended LRTI prevention schedule are freely available under India's Universal Immunisation Programme (UIP).

Bronchopneumonia emerged as the predominant LRTI pattern across all immunisation categories in our study, accounting for 40.0% of cases overall and rising sharply to 59.3% among non-immunised children. This finding aligns with Moharkar and Aglave<sup>1</sup> who similarly identified bronchopneumonia as the most frequent LRTI type, and with Srinivasa and Patel<sup>8</sup> who reported bronchopneumonia as the dominant diagnosis in under-five LRTI cases at a tertiary centre. The radiological correlation of clinical LRTI diagnoses, as documented by Hussain et al.<sup>9</sup> further confirms that pneumonia and bronchopneumonia represent the high-severity end of the LRTI spectrum most amenable to vaccine-preventable causative agents. The relatively higher proportion of acute bronchiolitis in immunised children may reflect the fact that bronchiolitis is predominantly caused by respiratory syncytial virus (RSV), for which routine vaccination was not available during the study period.

The highly significant association between incomplete immunisation and severe LRTI ( $p < 0.001$ ) corroborates published literature from South Asia and globally. The WHO-IMCI severity classification<sup>10</sup> used in our study provides a standardised, clinically validated framework for this comparison. The finding that severe disease was five times more prevalent in non-immunised (37.1%) versus fully immunised children (7.3%) is consistent with the meta-analytical estimates provided by Rudan et al.<sup>13</sup> who quantified the significant reduction in LRTI-related hospitalisation and case fatality attributable to pneumococcal and Hib conjugate vaccines. Scott et al.<sup>14</sup> similarly documented the decisive role of these vaccines in reducing burden of severe childhood pneumonia in developing-country settings, and our data provide region-specific corroboration of those findings.

The strong inverse gradient observed between immunisation status and frequency of LRTI episodes adds another clinically important dimension to the analysis. The finding that very frequent LRTI episodes ( $\geq 4$ /year) were nearly seven times more common in non-immunised (25.9%) versus fully immunised children (3.7%) aligns with the theoretical framework proposed by Chaturvedi<sup>4</sup> emphasising immunisation as a tool not merely for acute disease prevention but for reduction of recurrent respiratory morbidity. Adherence to the IAP recommended immunisation schedule<sup>12</sup> — which includes pentavalent vaccine, pneumococcal conjugate vaccine, and annual influenza vaccine — directly reduces the antigenic load of the most common bacterial and viral LRTI pathogens, thereby attenuating recurrence. The findings of Moharkar and Aglave<sup>1</sup> similarly documented that partial immunisation was associated with intermediate recurrence rates, confirming a dose-response protective relationship.

The clustering of adverse risk factors — malnutrition, overcrowding, kerosene fuel use, poor ventilation,

anaemia, parental illiteracy, and low socioeconomic status — in non-immunised and partially immunised children is a key finding with important public health implications. These factors are well-established as independent determinants of LRTI severity and recurrence, as documented by Savitha et al.<sup>6</sup> in their landmark analysis of modifiable LRTI risk factors in Indian children. Savitha and Gopalakrishnan<sup>7</sup> further demonstrated that rural residence combined with low parental education was the strongest predictor of incomplete immunisation. Park's Textbook of Preventive and Social Medicine<sup>11</sup> articulates this convergence of risk as a 'vulnerability cluster', wherein each individual risk factor amplifies the impact of the others. Our data confirm that interventions targeting immunisation cannot be considered in isolation — comprehensive child health programmes addressing nutrition, household environment, and parental literacy are required to maximise the protective effect of immunisation against LRTI.

The sex disparity of susceptibility to respiratory infection, that mainly comprises male children, is observed in our LRTI sample (dominated by male children, 57.6). Outcomes of research by Falagas et al.<sup>5</sup> prove that males are more susceptible and have a higher severity of LRTI, especially community-acquired pneumonia as their anatomy has different calibres of the airway, differences in immunological response, and, possibly, the behaviour of the males in seeking medical attention. The implication of this finding is on specific surveillance and early intervention in male children who present with respiratory symptoms especially where complete immunisation has not been achieved.

This study has certain limitations. Multiple factors that can arise out of the hospital-based design include the possibility of selection bias to the more severe presentations, which can overestimate severity in the population of LRTI in general. Health cards and parental recollection were taken as immunisation history, which introduces the potential misclassification bias. Cross-sectional type does not allow causal inference. Nevertheless, such limitations do not refute that the study offers valuable background information in the form of Chengalpattu District (setting that has not been previously used in the literature on LRTI-immunisation) and the strong statistical associations that can be seen in all three outcome dimensions (pattern, severity, frequency) give financial weight to the findings.

## 5. CONCLUSION

This experiment conclusively shows that immunisation status is a large and autonomous decider of the designs, severity, and regularity of LRTIs in kids below 12 years. Those children that were fully immunised tended to exhibit milder cases of LRTI with few episodes whereas the non-immunised children were disproportionately

affected with bronchopneumonia, severe disease and occurrence of LRTI. The synergic effect of malnutrition, overcrowding, indoor air pollution and illiteracy of parents, who have all been found to have significant links with incomplete immunisation, underscores the need of combined child health programs.

It is indeed necessary to expand the coverage of routine immunisation by use of community-based outreach, especially to rural, low-socioeconomic, and educationally disadvantaged families, to minimise the preventable burden of LRTI morbidity and mortality in this group. Primary and secondary care providers in healthcare must regularly evaluate and update immunisation records with each child attention in healthcare and missed immunisation opportunities should be actively talked about. To ensure the prevention of the LRTI burden as recorded in this study, the addition of newer vaccines to the universal immunisation programme and regular vaccination of all eligible children, especially, pneumococcal conjugate vaccine, Hib conjugate vaccine, and annual influenza vaccine, is the most direct and scalable route.

#### ACKNOWLEDGEMENTS

The authors have seriously recognized the Department of Pediatrics, Shri Sathya Sai Medical College and Research Institute, Chengalpattu, Tamil Nadu, as being supported by the institution. We thank all the participating kids as well as their families who expressed their cooperation, and data collection was helped by the clinical and nursing staff of the Pediatrics ward.

**Conflict of Interest:** None declared.

**Source of Funding:** This research received no external funding.

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