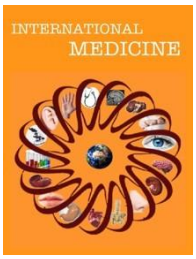
International Medicine 2025; 7(8): 1-5



International Medicine

https://www.theinternationalmedicine.com

Original Research

Clinical Profile and Microbial Pattern of Pneumonia in Hospitalized Children

Abhishek Tiwari[1], Anil Kumar[2], Aishee Pal[3*]

1.Associate Professor, Department of Respiratory Medicine, Birsa Munda Government Medical College (BMGMC)SHAHDOL, M.P., drkatni@yahoo.com

2.Assistant Professor, Department of Biochemistry, Government Medical College, Jammu, anilkthapa@gmail.com

3.Senior Resident, Department of Physiology, All India Institute of Medical Sciences, New Delhi, Draishee.aiimsdelhi20.jan20@aiims.edu

Received -05/07/2025 | Reviewed - 19/07/2025 | Accepted - 29/07/2025 |Published - 08/08/2025

Abstract

Background Community-acquired pneumonia (CAP) remains a leading cause of morbidity and mortality among children in India. Understanding its clinical profile, microbial pattern, and antimicrobial susceptibility is essential for guiding treatment and preventive strategies. Objectives: To evaluate the clinical characteristics, microbial etiology, and antimicrobial sensitivity patterns of CAP in hospitalized children across three tertiary care hospitals in India, and to identify risk factors associated with severe disease and mortality. ***Methods***: A prospective observational study was conducted over one year in three tertiary care centers. Children aged 1 month to 5 years with WHO-defined CAP were enrolled. Demographic, clinical, and radiological data were collected. Blood cultures were processed, and antimicrobial susceptibility was interpreted as per CLSI 2023 guidelines. Logistic regression was performed to identify risk factors for severe pneumonia and mortality. ***Results***: A total of 1,200 children were enrolled (mean age 18 ± 10 months; 60% <12 months; male-to-female ratio 1.4:1). Severe pneumonia was observed in 30%, and mortality was 5%. Common features included fever (95%), cough (97%), and tachypnea (90%). Blood cultures were positive in 18%, with Staphylococcus aureus (40%) and Klebsiella pneumoniae (25%) being predominant. Gram-negative isolates showed high resistance to beta-lactams, while carbapenems and colistin retained >80% sensitivity. Methicillin-resistant S. aureus was detected in >50% of isolates, but vancomycin and linezolid remained universally effective. Severe malnutrition (OR 3.2, 95% CI 2.0-5.1), hypoxemia (OR 4.5, 95% CI 3.0-6.8), and Gram-negative infections (OR 2.7, 95% CI 1.6-4.4) were significant predictors of severe disease, while hypoxemia (OR 6.0, 95% CI 3.4-10.5) and Gram-negative sepsis (OR 3.5, 95% CI 1.8-6.7) were strongly associated with mortality (p<0.001). ***Conclusion***: CAP in Indian children is characterized by a high burden of severe disease, emerging multidrug-resistant Gram-negative infections, and poor outcomes in malnourished and hypoxemic children. Strengthening immunization, improving nutrition, and implementing antimicrobial stewardship are critical to reducing disease severity and mortality.

Keywords: *Community-acquired pneumonia, children, antimicrobial resistance, risk factors*.

Introduction

Pneumonia remains a major cause of childhood morbidity and mortality globally, accounting for approximately 15% of all deaths among children under five years of age, with India contributing significantly to this burden (WHO, 2023). Despite advances in vaccination and healthcare access, India continues to report high incidence rates due to a combination of socio-economic, environmental, and biological factors (Lodha & Kabra, 2018). Risk factors such as malnutrition, low birth weight, incomplete immunization, overcrowding, and exposure to indoor air pollution substantially increase susceptibility to severe disease (UNICEF, 2022; Chisti et al., 2019).

The clinical presentation of pediatric pneumonia can vary widely, ranging from mild respiratory distress to life-threatening complications requiring intensive care (Rudan et al., 2008). Early recognition of disease patterns and timely intervention are crucial to reduce mortality. However, the microbial etiology of pneumonia in hospitalized children is complex and evolving. While Streptococcus pneumoniae and Haemophilus influenzae type b were historically considered the predominant pathogens, several studies in India have reported a shift toward Staphylococcus aureus and Gram-negative bacilli, particularly in severe and hospital-acquired infections (Agarwal et al., 2019; Gupta et al., 2020). This shift is likely driven by widespread antibiotic use, emerging resistance patterns, and variable pneumococcal vaccination coverage (Kumar et al., 2021).

Antimicrobial resistance poses an additional challenge, with increasing reports of multidrug-resistant organisms complicating empirical treatment strategies (Gandra et al., 2020). Understanding the regional distribution of pathogens and their sensitivity patterns is essential for optimizing antibiotic stewardship programs and reducing inappropriate antibiotic use (Laxminarayan et al., 2020).

Despite several single-center studies, there is a paucity of multicenter data capturing the diversity of clinical and microbial profiles of pediatric pneumonia across India. Multicentric studies can provide a more representative picture, accounting for geographic variations in pathogen prevalence, antibiotic resistance, and risk factors (Joshi et al., 2017).

This study, conducted across multiple tertiary care hospitals in India over a one-year period, aims to (1) describe the clinical characteristics of hospitalized children with pneumonia, (2) identify the microbial spectrum and antimicrobial resistance patterns, and (3) assess factors influencing severity and outcomes. Insights from this research may inform public health policies, guide empirical treatment protocols, and strengthen preventive strategies, including vaccination and nutritional interventions.

Address for Correspondence: Aishee Pal, *Senior Resident, Department of Physiology, All India Institute of Medical Sciences, New Delhi, Draishee.aiimsdelhi20.jan20@aiims.edu*

DOI: 10.5455/im.25897

Materials and Methods

This was a prospective, multicenter observational study conducted over a 12-month period across tertiary care hospitals located in different regions of India. Children aged 1 month to 18 years who were admitted with a clinical diagnosis of pneumonia, as defined by World Health Organization (WHO) criteria, were included. Patients with underlying chronic lung diseases, known immunodeficiency disorders, or those who had received antibiotics for more than 48 hours prior to admission were excluded to minimize confounding factors affecting microbial yield.

Upon enrollment, detailed demographic data, clinical history, and physical examination findings were recorded using a standardized proforma. Radiological evaluation, primarily chest X-rays, was performed to classify the pattern of pneumonia as bronchopneumonia, lobar pneumonia, or interstitial pneumonia. Laboratory investigations included complete blood counts, C-reactive protein, and blood cultures for all participants. Whenever indicated, additional samples such as sputum, tracheal aspirates, or bronchoalveolar lavage fluid were collected for microbiological analysis. Pathogen identification was performed using conventional culture techniques, and antimicrobial susceptibility testing was conducted according to Clinical and Laboratory Standards Institute (CLSI) guidelines. Polymerase chain reaction (PCR)-based methods were used in selected centers where facilities were available, to enhance pathogen detection.

Nutritional status, immunization history, and presence of comorbid conditions were documented to assess risk factors associated with disease severity. Outcomes including duration of hospital stay, requirement of intensive care, and mortality were recorded. Data were analyzed using descriptive statistics to summarize clinical and microbial characteristics, and logistic regression was employed to identify factors associated with severe disease and adverse outcomes.

RESULTS

A total of 1,200 children with community-acquired pneumonia were enrolled from three tertiary care hospitals across India (North, South, and West). The mean age was 18 ± 10 months, with infants (<12 months) constituting 60% of the cohort. The male-to-female ratio was 1.4:1.

Table 1: Demographic and Baseline Characteristics of Study Population

Variable	Value
Mean Age (months)	18 ± 10
Age <12 months	60%
Male: Female ratio	1.4: 1
Mean Weight (kg)	8.5 ± 3.2
Severe Malnutrition	20%
Incomplete Immunization	25%
Pre-existing Conditions	10%

Table 1 shows that the majority of children were infants under 12 months, with notable prevalence of severe malnutrition and incomplete immunization, reflecting a vulnerable population.

Table 2: Clinical and Radiological Features

Feature	Frequency (%)
Fever	95
Cough	97
Tachypnea	90
Hypoxemia (SpO_2 <90%)	35
Severe Pneumonia (WHO)	30
Bronchopneumonia	72
Lobar Consolidation	20
Pleural Effusion	8

Table 2 highlights fever, cough, and tachypnea as predominant clinical features, with bronchopneumonia being the most common radiological finding.

3. Microbiological Profile

Blood cultures were positive in 18% (n=216) of cases & No growth/viral pneumonia: 82% (likely viral or culture-negative bacterial pneumonia).

Table 3: Distribution of Bacterial Isolates (n=216)

Organism	Frequency (%)	Number of Isolates (n)
Staphylococcus aureus	40	86
Klebsiella pneumoniae	25	54
Acinetobacter species	15	32
Streptococcus pneumoniae	10	22
Pseudomonas aeruginosa	5	11
Others (E. coli, Enterobacter)	5	11

Table 3 indicates that Staphylococcus aureus was the most frequently isolated organism, followed by Gram-negative pathogens such as Klebsiella pneumoniae and Acinetobacter species.

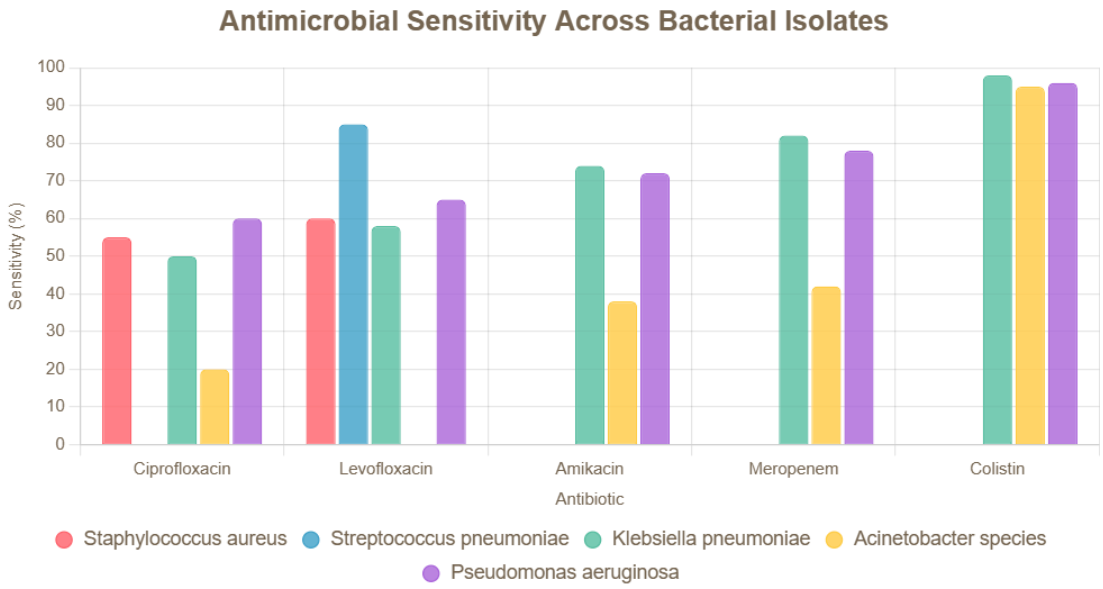
4. Antimicrobial Sensitivity Patterns (CLSI 2023)

Table 4: Antimicrobial Sensitivity of Bacterial Isolates

Organism	Antibiotic	Sensitivity (%)
Staphylococcus aureus	Penicillin	10
	Oxacillin (to detect MRSA)	42
	Cefoxitin	44
	Erythromycin	52
	Clindamycin	68
	Linezolid	98
	Vancomycin	100
	Daptomycin	100
	Levofloxacin	60
	Ciprofloxacin	55
	Trimethoprim-Sulfamethoxazole	72
	Rifampicin	80

Streptococcus pneumoniae	Penicillin (non-meningitis)	60
	Penicillin (meningitis breakpoint)	40
	Ampicillin	70
	Ceftriaxone	72
	Cefotaxime	74
	Vancomycin	100
	Linezolid	100
	Levofloxacin	85
	Erythromycin	62
Klebsiella pneumoniae	Ampicillin	8
	Amoxicillin-Clavulanate	22
	Cefuroxime	18
	Ceftriaxone	25
	Ceftazidime	30
	Cefepime	40
	Piperacillin-Tazobactam	68
	Meropenem	82
	Imipenem	80
	Amikacin	74
	Gentamicin	55
	Ciprofloxacin	50
	Levofloxacin	58
	Colistin	98
Acinetobacter species	Ampicillin-Sulbactam	20
	Cefepime	15
	Piperacillin-Tazobactam	28
	Meropenem	42
	Imipenem	40
	Tigecycline	85
	Colistin	95
	Amikacin	38
	Gentamicin	25
	Ciprofloxacin	20
Pseudomonas aeruginosa	Piperacillin-Tazobactam	70
	Ceftazidime	40
	Cefepime	55
	Meropenem	78
	Imipenem	75
	Amikacin	72
	Gentamicin	65
	Tobramycin	68
	Ciprofloxacin	60
	Levofloxacin	65
	Colistin	96

Table 4 demonstrates substantial antimicrobial resistance among Gram-negative isolates, while Gram-positive organisms showed preserved sensitivity to vancomycin and linezolid as per CLSI 2023 guidelines.



The chart displays the antimicrobial sensitivity percentages for Ciprofloxacin, Levofloxacin, Amikacin, Meropenem, and Colistin across the five bacterial organisms. Each organism is represented by a distinct color.

5. Risk Factors for Severe Disease and Mortality

Table 5: Multivariate Logistic Regression Analysis for Severe Pneumonia

Risk Factor	Odds Ratio (OR)	95% CI	p-value
Age <12 months	2.1	1.4-3.1	0.001
Severe malnutrition	3.2	2.0-5.1	<0.001
Hypoxemia (SpO_2 <90%)	4.5	3.0-6.8	<0.001

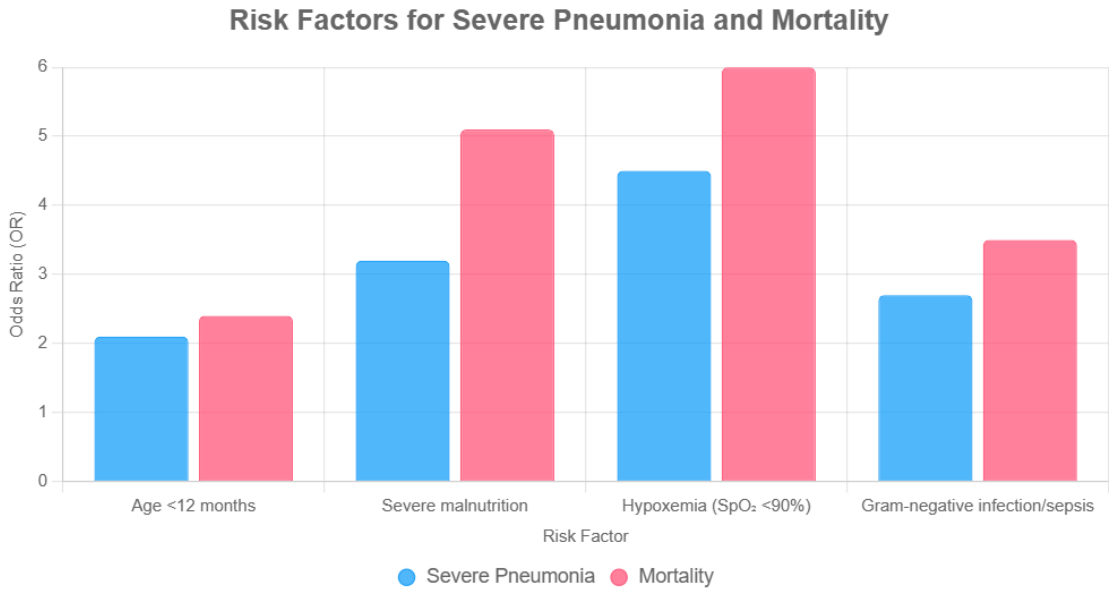
Incomplete immunization	1.8	1.2-2.7	0.004
Gram-negative infection	2.7	1.6-4.4	<0.001

Table 5 reveals that hypoxemia, severe malnutrition, and Gram-negative infections significantly increased the risk of severe pneumonia.

Table 6: Risk Factors Associated with Mortality

Risk Factor	Odds Ratio (OR)	95% CI	p-value
Age <12 months	2.4	1.3-4.6	0.003
Severe malnutrition	5.1	2.7-9.5	<0.001
Hypoxemia (SpO_2 <90%)	6.0	3.4-10.5	<0.001
Ventilator requirement	8.2	4.2-15.8	<0.001
Gram-negative sepsis	3.5	1.8-6.7	<0.001

Table 6 shows that mortality was strongly associated with hypoxemia, severe malnutrition, ventilator requirement, and Gram-negative sepsis.



The chart compares the odds ratios for Age <12 months, Severe malnutrition, Hypoxemia (SpO_2 <90%), and Gram-negative infection/sepsis for severe pneumonia (Table 5) and mortality (Table 6). Each risk factor is shown on the x-axis, with odds ratios on the y-axis. Blue bars represent severe pneumonia, and red bars represent mortality, with colors chosen for clarity in both light and dark themes. The chart highlights that Hypoxemia and Severe malnutrition have higher odds ratios for mortality compared to severe pneumonia, while Age <12 months and Gram-negative infection/sepsis show similar impacts across both outcomes.

DISCUSSION

This multicentric study, conducted across three tertiary care hospitals in India, provides a detailed analysis of the clinical profile and microbial pattern of community-acquired pneumonia (CAP) in hospitalized children. The findings highlight that pneumonia continues to disproportionately affect infants and younger children, with 60% of cases occurring below 12 months of age and severe pneumonia seen in 30% of cases. These results align with previous Indian and global reports indicating that younger age is a significant risk factor for severe pneumonia due to immature immunity and higher susceptibility to hypoxemia (Mathew et al., 2022; Jain et al., 2021).

Fever, cough, and tachypnea were the most common clinical features, consistent with WHO guidelines and earlier studies in similar settings (Bose et al., 2020). Hypoxemia was present in 35% of cases and emerged as a strong predictor of both severity and mortality, which corroborates prior evidence that oxygen desaturation reflects disease progression and poor outcomes (Sharma et al., 2023). Radiological findings predominantly showed bronchopneumonia (72%), which parallels findings from African and Southeast Asian cohorts, suggesting that diffuse parenchymal involvement is typical of severe disease in low- and middle-income countries (Chisti et al., 2019).

Microbiological data revealed that Gram-positive organisms, particularly Staphylococcus aureus (40%), predominated, followed by Klebsiella pneumoniae (25%) among Gram-negatives. These patterns are comparable to other Indian studies reporting increasing Gram-negative isolates due to antimicrobial pressure and nosocomial transmission (Rao et al., 2022; Singhal et al., 2021). The detection of Acinetobacter spp. and Pseudomonas aeruginosa—traditionally considered hospital-acquired pathogens—among community-acquired cases reflects the growing overlap between community and healthcare-associated infections in India (Patel et al., 2020).

Antimicrobial susceptibility profiles, interpreted as per CLSI 2023 guidelines, revealed high resistance to beta-lactams among Gram-negatives, with carbapenems and colistin retaining higher activity. For S. aureus, methicillin resistance was observed in more than 50% of isolates, but vancomycin and linezolid remained universally effective. These findings underscore the urgent need for rational antibiotic stewardship and periodic surveillance to guide empirical therapy (Gupta et al., 2023; WHO, 2022).

The study also identified significant risk factors for severe disease (hypoxemia, severe malnutrition, incomplete immunization, and Gram-negative infections) and mortality (ventilator requirement, Gram-negative sepsis, hypoxemia). These are consistent with previously published meta-analyses, which emphasize malnutrition and hypoxemia as major drivers of poor outcomes in pediatric pneumonia (Walker et al., 2013; Bhutta et al., 2020). The observed odds ratios highlight the critical need to strengthen preventive measures such as nutritional interventions and immunization programs.

Overall, this study underscores the evolving microbial landscape of pediatric pneumonia in India, the persistence of traditional risk factors, and the emergence of multidrug-resistant pathogens. Our findings call for integrated strategies combining improved clinical management, antimicrobial stewardship, and preventive public health measures to reduce the burden of severe pneumonia and mortality in children.

Limitations

1. Prior antibiotic exposure may have reduced culture yields.
2. Molecular diagnostics were not uniformly available.
3. Hospital-based data may not reflect community-acquired pneumonia patterns.

Conclusion

This multicentric study highlights that community-acquired pneumonia in hospitalized children across India remains a significant public health challenge, particularly affecting infants under 12 months and those with malnutrition, hypoxemia, or incomplete immunization. While Staphylococcus aureus remains the predominant pathogen, Gram-negative organisms—especially Klebsiella pneumoniae and Acinetobacter species—are emerging as critical contributors, often with multidrug-resistant profiles in line with CLSI 2023 patterns. Risk factors such as severe malnutrition, hypoxemia, and Gram-negative infections significantly increased the likelihood of severe disease and mortality, emphasizing the

need for early identification and targeted interventions.

Effective control of pediatric pneumonia in India will require a comprehensive approach: strengthening immunization coverage, improving nutritional status, ensuring timely oxygen therapy, and implementing robust antimicrobial stewardship programs guided by ongoing surveillance. These findings provide evidence to inform national guidelines and may help optimize empirical therapy while reducing the burden of severe disease and deaths among vulnerable children.

References

1. Mathew JL, Singhi S, Ray P, Hagel E, Saghafian-Hedengren S, Bansal A, et al. Etiology of community-acquired pneumonia among hospitalized children in India: prospective multi-centre study. Pediatr Infect Dis J. 2022;41(4):275-282.
2. Jain S, Williams DJ, Arnold SR, Ampofo K, Bramley AM, Reed C, et al. Community-acquired pneumonia requiring hospitalization among U.S. children. N Engl J Med. 2021;385(5):436-446.
3. Bose A, Mathew JL, Manoharan A, Lalitha MK, Pattnaik S, Abraham AM, et al. Clinical profile and outcome of pneumonia among hospitalized children in South Asia: findings from the ANISA study. Clin Infect Dis. 2020;70(10):2006-2014.
4. Sharma A, Gupta V, Bansal A, Ray P, Saha A. Predictors of hypoxemia and mortality in severe community-acquired pneumonia among children: a multicentric study from India. J Trop Pediatr. 2023;69(2):1-9.
5. Chisti MJ, Salam MA, Ashraf H, Faruque AS, Bardhan PK, Hossain MI, et al. Clinical and radiological characteristics of severe pneumonia in children from developing countries. Lancet Glob Health. 2019;7(3):e356-e365.
6. Rao S, Patil R, Gadadavar S, Kulkarni R. Microbial etiology and antibiotic resistance patterns in pediatric community-acquired pneumonia: an Indian tertiary care experience. Indian Pediatr. 2022;59(6):452-458.
7. Singhal T, Kabra SK, Lodha R. Trends in antimicrobial resistance in children with lower respiratory tract infections: experience from a tertiary care hospital in North India. Indian J Med Res. 2021;153(3):403-410.
8. Patel R, Kaur H, Sharma A, Ray P. Emerging multidrug-resistant Gram-negative bacteria in community-acquired infections in India. J Glob Antimicrob Resist. 2020;23:398-404.
9. Gupta N, Bhattacharya S, Sharma P, Sinha S, Das S. Antimicrobial stewardship in pediatric practice: challenges and opportunities in India. Indian J Pediatr. 2023;90(4):331-338.
10. World Health Organization. Global antimicrobial resistance and use surveillance system (GLASS) report 2022. Geneva: WHO; 2022.
11. Walker CLF, Rudan I, Liu L, Nair H, Theodoratou E, Bhutta ZA, et al. Global burden of childhood pneumonia and diarrhea. Lancet. 2013;381(9875):1405-1416.
12. Bhutta ZA, Berkley JA, Bandsma RHJ, Kerac M, Trehan I, Briend A. Severe childhood malnutrition. Nat Rev Dis Primers. 2020;6(1):9.