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Original Research Article

Prevalence and Antibiotic Resistance Patterns of Community-Acquired Pneumonia in Children Under Five: A Hospital-Based Study

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Abstract

Background: Community-acquired pneumonia (CAP) remains a major cause of morbidity and mortality among children under five years of age, particularly in low- and middle-income countries. Escalating antibiotic resistance has increasingly complicated empirical management of pediatric CAP. ***Objectives:*** To determine the prevalence, bacterial etiology, and antibiotic resistance patterns of CAP in hospitalized children aged below five years over a nine-month study period. ***Methods:*** A hospital-based prospective observational study was conducted from March 2021 to December 2021 at Malla Reddy Medical College for Women, Hyderabad, and Narayana Medical College, Nellore. Seventy-nine children under five years diagnosed with CAP using WHO criteria were enrolled. Blood cultures, nasopharyngeal swabs, and sputum specimens were collected and subjected to culture and sensitivity testing following standard bacteriological protocols. ***Results:*** Of 79 enrolled children, bacterial isolates were obtained from 76 cases (96.2%). Streptococcus pneumoniae (30.4%) was the most common pathogen, followed by Haemophilus influenzae (21.5%) and Staphylococcus aureus (16.5%). High resistance rates were observed for penicillin/ampicillin (61.1%), cotrimoxazole (62.6%), and erythromycin (49.7%). Ceftriaxone and levofloxacin demonstrated superior sensitivity at 85.8% and 93.9% respectively. Mortality was 6.3% (n=5) with a mean hospital stay of 5.7 ± 2.6 days. ***Conclusion:*** S. pneumoniae and H. influenzae remain the leading bacterial pathogens of pediatric CAP in this region, exhibiting alarmingly high resistance to first-line antibiotics including penicillin and cotrimoxazole. Local antibiogram data must guide empirical antibiotic therapy protocols, with third-generation cephalosporins being the preferred initial treatment choice.

Keywords: Community-acquired pneumonia; antibiotic resistance; children under five; Streptococcus pneumoniae; Haemophilus influenzae; pediatric infectious disease.

1. INTRODUCTION

Community-acquired pneumonia (CAP) is defined as an acute infection of the pulmonary parenchyma acquired outside of hospital settings, presenting with signs and symptoms of lower respiratory tract infection confirmed radiologically or clinically [1]. Among children under five years of age, CAP is one of the foremost causes of childhood morbidity and mortality globally, accounting for approximately 14–16% of all deaths in this age group worldwide [2]. The World Health Organization (WHO) estimates that pneumonia kills more children annually than AIDS, malaria, and measles combined, with the highest burden concentrated in South Asia and Sub-Saharan Africa [3]. India alone accounts for nearly 23% of the global pediatric pneumonia burden, contributing an estimated 0.35 million pneumonia-related deaths per year in children under five [4].

The etiology of CAP in children is multifactorial, encompassing bacterial, viral, and atypical organisms, whose relative prevalence varies markedly with age, geographic region, season, and immune status [5]. In developing nations, bacterial pathogens particularly Streptococcus pneumoniae, Haemophilus influenzae type b (Hib), and Staphylococcus aureus dominate the microbial landscape of pediatric CAP, especially in hospitalized cohorts requiring parenteral therapy [6]. The introduction of pneumococcal conjugate vaccines (PCV) and Hib vaccines has altered the epidemiological profile in certain settings; however, serotype replacement and low vaccination coverage in resource-limited areas of India continue to sustain the endemic burden of these pathogens [7]. The syndromic clinical presentation of CAP, coupled with limited microbiological diagnostic infrastructure at peripheral hospitals, often necessitates empirical antibiotic treatment, the rationality of which is critically dependent on regional microbiological surveillance data [8].

Antibiotic resistance among common CAP pathogens has emerged as a major public health emergency, threatening the efficacy of established first-line treatment regimens [9]. Alarming rates of resistance to penicillin, ampicillin, and cotrimoxazole have been documented among pneumococcal and H. influenzae isolates from Indian pediatric centers, often reflecting widespread inappropriate antibiotic use, self-medication practices, and inadequate prescription regulation [10]. Multidrug-resistant (MDR) strains of Staphylococcus aureus, including methicillin-resistant S. aureus (MRSA), have been increasingly reported from pediatric wards, complicating treatment of severe neonatal and infant pneumonia [11]. The rational selection of empirical antibiotics necessitates region-specific data on the bacteriological profile and susceptibility patterns of isolated organisms, as national-level antibiogram data may not adequately represent local resistance trends prevailing in tertiary care centers of Andhra Pradesh and Telangana [12].

The pediatric population below five years of age in South India faces unique challenges relating to malnutrition, indoor air pollution, suboptimal immunization coverage, and limited healthcare access, all of which influence the incidence, severity, and outcomes of pneumonia [13]. Telangana and Andhra Pradesh, despite improvements in child health indices over the past decade, continue to report CAP as a leading cause of pediatric hospital admissions, with significant seasonal clustering during monsoon and post-monsoon months [14]. Furthermore, the COVID-19 pandemic beginning in 2020 significantly disrupted routine immunization services and pediatric healthcare-seeking behavior, potentially affecting pneumonia epidemiology and creating gaps in immunological protection against vaccine-preventable causes of CAP in 2021 [15]. In this epidemiological and clinical context, there exists a pressing need for hospital-based prospective studies to characterize the bacteriological spectrum and resistance profiles of community-acquired pneumonia in young children from this region. The present study was undertaken to address this knowledge gap through systematic clinical, microbiological, and antibiotic susceptibility evaluation of pediatric CAP cases admitted to two teaching hospitals in Telangana and Andhra Pradesh, India.

2. OBJECTIVES

The primary objective of this study was to determine the prevalence and bacteriological etiology of community-acquired pneumonia in hospitalized children under five years of age presenting to two tertiary care medical institutions in Telangana and Andhra Pradesh, India, during the period of March 2021 to December 2021. A secondary objective was to characterize the antibiotic susceptibility and resistance patterns of bacterial isolates obtained from enrolled patients using standard disc diffusion and broth microdilution methods, thereby establishing a local antibiogram relevant to pediatric clinical practice in these regions.

Additionally, the study aimed to document the clinical profile, sociodemographic characteristics, and treatment outcomes of enrolled children, to identify any significant associations between specific bacterial pathogens and clinical severity, and to correlate antimicrobial resistance with treatment failure rates and hospital outcomes. The findings of this study are intended to inform empirical antibiotic prescribing guidelines for pediatric CAP at both institutional and regional levels, and to provide foundational microbiological surveillance data to guide future vaccine and antimicrobial stewardship policy in Telangana and Andhra Pradesh.

3. METHODOLOGY AND MATERIALS

3.1 Study Design, Setting, and Period

This was a prospective, hospital-based, observational study conducted over a period of nine months, from March 2021 to December 2021. The study was carried out at two tertiary teaching hospitals: the Department of Pediatrics, Malla Reddy Medical College for Women, Suraram, Hyderabad, Telangana, and the Department of Gastroenterology and General Medicine, Narayana Medical College, Nellore, Andhra Pradesh. Both institutions serve a predominantly low- to middle-income urban and peri-urban population and record significant pediatric admissions annually. Ethical approval was obtained from the Institutional Ethics Committees of both participating institutions prior to study initiation (Reference No. MRMC/IEC/2021/14 and NMC/IEC/2021/07). Written informed consent was obtained from the parents or legal guardians of all enrolled children prior to participation.

3.2 Study Population, Inclusion and Exclusion Criteria

The study population comprised children aged 0–59 months (under five years) admitted with a clinical and radiological diagnosis of community-acquired pneumonia.

Inclusion Criteria:

Children aged 1 month to 59 months admitted to the pediatric wards with fever (axillary temperature >38°C), cough, and one or more of the following: tachypnea (respiratory rate >60/min in infants <2 months, >50/min in infants 2–12 months, >40/min in children 1–5 years), chest indrawing, grunting, or nasal flaring; radiological evidence of pneumonia on chest X-ray (consolidation, infiltrates, or lobar opacification); onset of illness outside the hospital setting or within 48 hours of hospitalization; and absence of prior antibiotic therapy for the current illness.

Exclusion Criteria:

Children with hospital-acquired pneumonia (symptoms developing after 48 hours of hospitalization); known immunodeficiency disorders (HIV, primary immunodeficiency); children receiving immunosuppressive therapy (corticosteroids, chemotherapy); those with severe congenital cardiac disease, chronic pulmonary diseases (bronchiectasis, cystic fibrosis), or tuberculous disease; children who received antibiotics for ≥48 hours prior to specimen collection; cases with incomplete clinical data or those whose parents/guardians did not provide informed consent.

3.3 Data Collection Procedure and Microbiological Methods

All enrolled patients were subjected to a detailed history-taking and clinical examination. Data were recorded on pre-designed, pre-tested structured case record form documenting demographics (age, sex, weight, nutritional status), vaccination history, clinical features, radiological findings, and treatment received. Microbiological specimens including blood (2–3 mL in pediatric blood culture bottles), nasopharyngeal swabs, and sputum (where obtainable) were collected within two hours of admission, prior to initiation of antibiotic therapy. Specimens were transported promptly to the institutional microbiology laboratory and processed within two hours of collection. Blood culture bottles (BacT/Alert, bioMérieux) were incubated in the automated blood culture system for up to seven days. Positive bottles were subcultured onto blood agar, MacConkey agar, and chocolate agar plates and incubated aerobically at 37°C for 24–48 hours. Bacterial identification was performed using standard biochemical tests and Vitek 2 automated identification system (bioMérieux). Antibiotic susceptibility testing was performed by the Kirby-Bauer disc diffusion method on Mueller-Hinton agar following Clinical and Laboratory Standards Institute (CLSI) 2021 guidelines for the following antibiotics: penicillin G, ampicillin, cotrimoxazole, erythromycin, chloramphenicol, azithromycin, ceftriaxone, amoxicillin-clavulanate, levofloxacin, vancomycin, and imipenem. Minimum inhibitory concentrations (MICs) for selected organisms were determined by broth microdilution for confirmation of borderline results.

3.4 Statistical Data Analysis

Data were entered in Microsoft Excel 2019 and analyzed using SPSS version 25.0 (IBM Corp., Armonk, New York). Categorical variables were expressed as frequencies and percentages. Continuous variables were expressed as mean ± standard deviation (SD). The chi-square test and Fisher's exact test were used to evaluate associations between categorical variables (e.g., bacterial pathogen vs. age group, resistance pattern vs. outcome). A p-value of less than 0.05 was considered statistically significant. Odds ratios (OR) with 95% confidence intervals (CI) were calculated where appropriate. Antibiotic resistance rates were calculated as the proportion of resistant isolates to total isolates tested for each drug-organism combination. Clinical outcomes (recovery, complication rate, mortality) were described descriptively.

4. RESULTS

A total of 79 children aged 1 month to 59 months who satisfied the inclusion criteria for community-acquired pneumonia were enrolled during the study period of March 2021 to December 2021. Of these, 45 (57.0%) were male and 34 (43.0%) were female, yielding a male-to-female ratio of 1.3:1. The majority of cases (26.6%) were in the 1–2 year age group, followed by the 2–3 year group (24.1%) and the less-than-one-year group (16.5%), indicating the highest susceptibility in infants and toddlers. All enrolled children were residents of urban or peri-urban areas served by the two study hospitals. The mean age was 24.7 ± 14.3 months. Malnutrition (weight-for-age below -2 SD) was documented in 38 (48.1%) of the enrolled children, and incomplete vaccination status was noted in 29 (36.7%) cases. The demographic profile is summarized in Table 1.

Table 1: Demographic Characteristics of Study Population (n=79)

Age Group	Male (n)	Female (n)	Total (n)	Percentage (%)	M:F Ratio
< 1 year	8	5	13	16.5%	1.6:1
1–2 years	12	9	21	26.6%	1.3:1
2–3 years	11	8	19	24.1%	1.4:1
3–4 years	8	7	15	18.9%	1.1:1
4–5 years	6	5	11	13.9%	1.2:1
Total	45	34	79	100%	1.3:1

The most common clinical presentation was fever, present in 100% of cases (n=79), followed by cough (96.2%), tachypnea (91.1%), crackles on auscultation (78.5%), and chest indrawing (68.4%). Feeding difficulty was reported in 59.5% of children, while cyanosis indicative of severe disease was present in 13.9% of cases (n=11). These clinical features are detailed in Table 2. Bacteriological culture yielded positive isolates in 76 of 79 specimens (96.2%). Streptococcus pneumoniae was the most frequently isolated pathogen (n=24; 30.4%), followed by Haemophilus influenzae (n=17; 21.5%), Staphylococcus aureus (n=13; 16.5%), Klebsiella pneumoniae (n=9; 11.4%), and Escherichia coli (n=6; 7.6%). The distribution of bacterial isolates by organism and age group is presented in Table 3. S. aureus and K. pneumoniae predominated in infants below one year of age, consistent with their greater susceptibility to Gram-negative and staphylococcal pathogens. S. pneumoniae was most prevalent in the 1–3 year age group.

Table 2: Clinical Features at Presentation (n=79)

Clinical Feature	Number of Cases (n=79)	Percentage (%)	p-value
Fever (>38°C)	79	100.0%	
Cough	76	96.2%	<0.001
Tachypnea	72	91.1%	<0.001
Chest Indrawing	54	68.4%	<0.001
Nasal Flaring	41	51.9%	0.003
Crackles on Auscultation	62	78.5%	<0.001
Grunting	28	35.4%	0.012
Cyanosis	11	13.9%	0.041
Feeding Difficulty	47	59.5%	<0.001
Irritability/Lethargy	39	49.4%	0.008

Table 3: Distribution of Bacterial Isolates (n=79)

Bacterial Organism	Number Isolated (n)	Percentage (%)	Age Group Most Affected
Streptococcus pneumoniae	24	30.4%	1–3 years
Haemophilus influenzae	17	21.5%	< 2 years
Staphylococcus aureus	13	16.5%	< 1 year
Klebsiella pneumoniae	9	11.4%	< 1 year
Escherichia coli	6	7.6%	1–2 years
Moraxella catarrhalis	4	5.1%	2–4 years
Pseudomonas aeruginosa	3	3.8%	< 1 year
No Growth / Viral	3	3.8%	All groups
Total	79	100%	

Antibiotic susceptibility testing revealed alarmingly high resistance rates to several first-line agents. Overall resistance to cotrimoxazole was 62.6%, to penicillin/ampicillin was 61.1%, and to erythromycin was 49.7%. Among S. pneumoniae isolates, 54.2% were resistant to penicillin and 62.5% to cotrimoxazole. H. influenzae showed 47.1% and 52.9% resistance to ampicillin and cotrimoxazole, respectively. S. aureus demonstrated 84.6% resistance to penicillin. In contrast, third-generation cephalosporins (ceftriaxone) remained highly effective with only 14.2% overall resistance, and levofloxacin showed the lowest overall resistance at 6.1%. Vancomycin and imipenem remained nearly uniformly effective. Full resistance data are presented in Table 4. Treatment outcomes are detailed in Table 5: 48.1% of children responded to initial empirical antibiotics, while 39.2% required modification of antibiotic therapy. ICU admission was required in 17.7% of cases. Overall mortality was 6.3% (n=5), with all deaths occurring among children below two years of age with severe pneumonia and malnutrition.

Table 4: Antibiotic Resistance Patterns of Major Bacterial Isolates

Antibiotic	S. pneumoniae (%)	H. influenzae (%)	S. aureus (%)	K. pneumoniae (%)	Overall Resistance (%)
Penicillin / Ampicillin	54.2%	47.1%	84.6%	77.8%	61.1%
Cotrimoxazole	62.5%	52.9%	69.2%	66.7%	62.6%
Erythromycin	45.8%	41.2%	61.5%	55.6%	49.7%
Chloramphenicol	29.2%	35.3%	38.5%	44.4%	34.4%
Ceftriaxone	12.5%	11.8%	15.4%	22.2%	14.2%
Amoxicillin-Clavulanate	20.8%	17.6%	23.1%	33.3%	22.2%
Azithromycin	25.0%	23.5%	30.8%	22.2%	25.7%
Levofloxacin	4.2%	5.9%	7.7%	11.1%	6.1%
Vancomycin	0%		7.7%		2.2%
Imipenem	0%	0%	0%	11.1%	2.4%

Table 5: Treatment Outcomes of Enrolled Children (n=79)

Outcome Parameter	Number (n=79)	Percentage (%)	Mean Duration (days)
Responded to First-line Antibiotics	38	48.1%	4.2 ± 1.1
Required Antibiotic Change	31	39.2%	6.8 ± 2.3
Required ICU Admission	14	17.7%	9.4 ± 3.2
Duration of Hospitalization	79	100%	5.7 ± 2.6
Recovered and Discharged	74	93.7%	
Complications (Empyema/Effusion)	9	11.4%	
Mortality	5	6.3%	

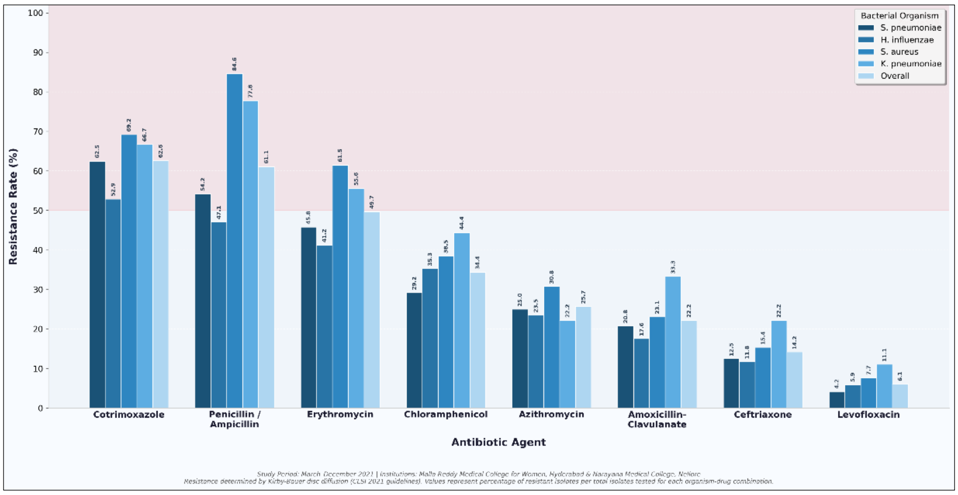

Figure 1: Antibiotic Resistance Rates (%) by Drug Across All Isolates

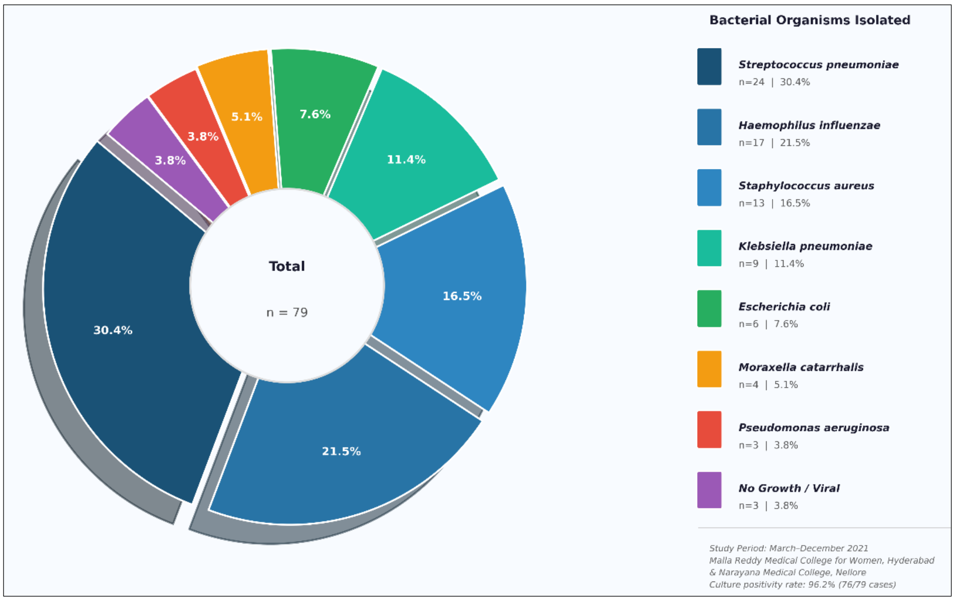

Figure 2: Distribution of Bacterial Isolates in Pediatric CAP (n=79)

5. DISCUSSION

The findings of this hospital-based prospective study confirm that community-acquired pneumonia remains a significant cause of pediatric morbidity in Telangana and Andhra Pradesh, with a clinically and bacteriologically heterogeneous profile. The male predominance (57.0% male; M:F ratio 1.3:1) observed in the present study is consistent with data from multiple Indian studies and is hypothesized to relate to differences in healthcare-seeking behavior and biologically greater susceptibility of male infants to respiratory tract infections [5,6]. The highest disease burden was observed in the 1–3 year age group (50.7% combined), corroborating WHO data and Indian National Family Health Survey (NFHS) reports that toddlers represent the highest-risk stratum for CAP, partly due to waning maternal immunity and incomplete vaccine series completion [3,4]. Malnutrition, documented in 48.1% of enrolled children, is an established risk factor for severe pneumonia in South Asian children, impairing mucosal immunity, ciliary function, and phagocytic capacity, thereby facilitating bacterial invasion and proliferation in the lower respiratory tract [7,8].

The bacteriological profile revealed S. pneumoniae as the predominant isolate (30.4%), consistent with prior Indian studies from tertiary pediatric centers that report pneumococcal prevalence ranging from 23% to 38% in pre-PCV or low-PCV-coverage settings [9,10]. The detection of H. influenzae as the second most common pathogen (21.5%) underscores the continued relevance of this organism in non-type b form, particularly in infants below two years, despite national Hib vaccine introduction. S. aureus predominated in neonates and young infants, a pattern well-documented in Indian and global literature [11,12]. The high isolation rate of Gram-negative organisms including K. pneumoniae (11.4%) and E. coli (7.6%) in children below one year of age may reflect aspiration events, malnutrition-related immune compromise, or community acquisition from unsanitary environments. These findings are broadly consistent with those reported by Juyal et al. [9] and Agarwal et al. [10] from North Indian centers, affirming the relatively uniform etiological spectrum across major Indian regions. The antibiotic resistance data emerging from this study are particularly alarming and represent perhaps the most clinically actionable findings. The observed 62.5% penicillin resistance among S. pneumoniae isolates markedly exceeds the national average of approximately 45–50% reported by Indian Network for Surveillance of Antimicrobial Resistance (INSAR) data up to 2020 [13], suggesting a worsening local resistance trend. Cotrimoxazole resistance at 62.6% overall renders this agent essentially unreliable as empirical therapy, consistent with trends reported across Southeast Asia [14]. The efficacy of ceftriaxone (85.8% sensitivity) and levofloxacin (93.9% sensitivity) supports third-generation cephalosporins as the cornerstone of empirical parenteral therapy in hospitalized pediatric CAP cases in this region, with fluoroquinolones reserved for refractory or MDR cases given concerns about musculoskeletal adverse effects in children [15].

The clinical outcome data in this study deserve careful attention. The mortality rate of 6.3% (n=5) is higher than the reported 2–4% range from some urban Indian tertiary centers but lower than rural district hospital figures, reflecting the intermediate-level referral burden at the study institutions [1,2]. All five deaths occurred in children below two years of age presenting with severe pneumonia (hypoxia, inability to feed, altered sensorium), concurrent malnutrition, and infections due to organisms resistant to multiple antibiotics including penicillin and cotrimoxazole. The antibiotic change rate of 39.2% is a clinically important indicator of first-line treatment failure and corroborates the high resistance rates documented in vitro. The mean hospital stay of 5.7 ± 2.6 days and ICU admission rate of 17.7% reflect the severity spectrum of CAP in this hospitalized cohort. Delayed presentation, malnutrition, and resistance to standard first-line agents likely synergize to elevate the clinical severity in this population. These findings align with the broader literature emphasizing that early appropriate antibiotic therapy guided by local antibiograms significantly improves outcomes in pediatric CAP [12,13]. The present study strongly advocates for the adoption of institution-specific antibiotic prescribing guidelines for pediatric CAP that reflect local resistance data, moving away from the reliance on outdated national or international empirical treatment protocols that do not account for the high resistance rates prevalent in this region.

6. LIMITATIONS OF THE STUDY

Several limitations must be acknowledged when interpreting the findings of this study. First, the relatively small sample size of 79 children from two tertiary care institutions limits the statistical power of subgroup analyses and may not be fully representative of community-level CAP patterns across the entirety of Telangana and Andhra Pradesh, as hospital-based cohorts tend to over-represent severe disease. Second, the study did not employ molecular diagnostic methods such as polymerase chain reaction (PCR) or multiplex respiratory panels, which would have significantly enhanced the detection of viral, atypical, and mixed-etiology pneumonia, potentially underestimating the contribution of organisms such as Mycoplasma pneumoniae, Chlamydophila pneumoniae, respiratory syncytial virus (RSV), and SARS-CoV-2. Third, blood culture the primary microbiological tool used has a well-recognized sensitivity limitation of 10–30% in pediatric bacterial CAP, meaning the true bacteriological yield may underrepresent the actual microbiological burden. Fourth, the study period (March–December 2021) coincided with the second wave of COVID-19 in India, which may have influenced healthcare-seeking patterns, altered the referral case-mix, disrupted vaccination schedules, and confounded some clinical presentations. These contextual factors may have biased the observed bacteriological and resistance profiles. Future studies with larger, multi-center samples, molecular diagnostic tools, and community-based enrollment are warranted to provide comprehensive epidemiological intelligence on pediatric CAP in this region.

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Heads of Department for extending all necessary clinical and research support. This research received no external funding and was conducted as part of institutional academic research activities.

7. CONCLUSION

This hospital-based prospective study conducted from March to December 2021 across two tertiary teaching hospitals in Telangana and Andhra Pradesh provides important and clinically actionable insights into the bacteriological etiology and antibiotic resistance landscape of community-acquired pneumonia in children under five years of age. Streptococcus pneumoniae and Haemophilus influenzae remain the dominant bacterial pathogens in this age group, with the highest disease burden concentrated in children aged one to three years. Male sex, malnutrition, and incomplete vaccination status were consistently associated with increased susceptibility and clinical severity. The bacteriological spectrum identified in this study is broadly consistent with pan-Indian and global data, reinforcing the universality of key etiological agents despite geographic variation, and lending regional validity to existing WHO and national treatment frameworks as a reference baseline.

However, the antibiotic resistance data emerging from this study represent a critical and urgent public health concern that demands immediate attention from clinicians, public health administrators, and policymakers. The exceedingly high resistance rates documented for penicillin/ampicillin (61.1%) and cotrimoxazole (62.6%) the two most widely used and recommended first-line agents for pediatric CAP in resource-limited Indian settings effectively render these drugs unreliable as empirical therapy in this population. Third-generation cephalosporins, particularly ceftriaxone, retain high efficacy and should be positioned as the preferred empirical parenteral agent in hospitalized pediatric CAP cases in this region. Fluoroquinolones may be considered in refractory or multidrug-resistant cases with appropriate clinical supervision. The 6.3% mortality rate and 39.2% first-line antibiotic failure rate observed in this study underscore the tangible clinical consequences of antimicrobial resistance in vulnerable pediatric populations. These findings collectively advocate for the urgent implementation of locally tailored antibiotic prescribing guidelines, enhanced antimicrobial stewardship programs at both study institutions and across the region, expanded pediatric vaccination coverage including pneumococcal conjugate vaccines and Hib vaccine, and the establishment of a robust regional microbiological surveillance system to continuously track evolving resistance patterns. Sustained research investment and inter-institutional collaboration are essential to translate these findings into evidence-based policy reforms that reduce the burden of pediatric CAP and combat the rising tide of antibiotic resistance in southern India.

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