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Study of the clinical profile of community-acquired pneumonia: a cross-sectional study in northeast India

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Abstract

Community-acquired pneumonia (CAP) continues to pose a significant public health burden in India, particularly in the northeastern region, where data on microbial etiology and resistance patterns remain scarce. This cross-sectional observational analytical study, conducted over one year at a tertiary care center in northeast India, analyzed 117 adult patients with clinico-radiologically confirmed CAP to elucidate their clinical, epidemiological, and microbiological profiles. The cohort was predominantly male (76.9%), with a mean age of 52 years, and the most affected age group was 31-40 years. Hypertension and chronic obstructive pulmonary disease were the most common comorbidities. Cough, breathlessness, and fever were the leading symptoms. Sputum cultures were positive in 42.7% of cases, with a striking predominance of gram-negative organisms (94%), especially *Klebsiella pneumoniae* and *Pseudomonas* species. Alarmingly, high resistance rates were observed for widely used antibiotics such as ceftriaxone and cefuroxime, while meropenem, amikacin, and ertapenem retained high sensitivity. These findings emphasize the critical need for tailored, region-specific empirical treatment strategies in light of emerging antibiotic resistance trends in CAP.

Key words: community-acquired pneumonia, northeastern India, bacteriological profile, antibiotic resistance, empirical treatment.

Introduction

Community-acquired pneumonia (CAP) remains a major health challenge in India, a leading cause of elderly morbidity and mortality despite effective antibiotics [1]. Its etiology varies geographically, complicating empirical treatment, especially in northeastern India where data is scarce. Reliable regional data on causative organisms, combined with clinical, laboratory, and radiological findings, are essential to guide antibiotic choices amid rising resistance. CAP incidence peaks in the very young and elderly, with mortality highest above 65 years (14% in hospitalized patients) [2-5]. Common pathogens include *Streptococcus pneumoniae* (20-60%), *Chlamydia pneumoniae* (4-6%), *Haemophilus influenzae* (3-10%), *Legionella* (2-8%), *Mycoplasma pneumoniae* (1-6%), *Staphylococcus aureus* (3-5%), gram-negative bacilli (3-5%), and viruses (2-13%), yet 40-60% of cases lack an identifiable cause, and 2-5% involve multiple organisms [5,6]. Definitive microbiological diagnosis is ideal to counter treatment failure, but most therapy relies on empirical approaches targeting the most likely pathogen based on clinical and radiological clues. Evaluation aims to confirm diagnosis, rule out mimics, pinpoint etiology, assess severity, and track complications. In northeastern India, limited etiological knowledge hinders tailored treatment. Understanding the local clinical and epidemiological profile could optimize the empirical antibiotic decisions, improving probable outcomes in this high-burden region.

Materials and Methods

Study design and setting

We conducted a prospective, cross-sectional observational analytical study at the Department of General Medicine, North Eastern Indira Gandhi Regional Institute of Health and Medical Sciences (NEIGRIHMS), a tertiary-care academic hospital in Shillong, Meghalaya, India. The study period extended from January 1, 2020, to December 31, 2020. This design was selected to allow a comprehensive assessment of the clinical, radiological, and microbiological features of CAP in adults presenting to this facility, and to evaluate antibiotic resistance patterns among bacterial isolates. The study was approved by the Institutional Ethics Committee of NEIGRIHMS (Ref No. NEIGR/IEC/M10/T12/2020). Written informed consent was obtained from all participants, or from legally authorized representatives in cases where patients were unable to provide consent.

Eligibility criteria

Patients were eligible for inclusion if they were aged 18 years or older and had a clinical diagnosis of community-acquired pneumonia confirmed by chest imaging. The diagnosis was based on the presence of new infiltrates on chest radiograph or computed tomography (CT),

accompanied by at least one lower respiratory tract symptom (e.g., cough, sputum production, or dyspnea) and at least one systemic sign (e.g., fever, chills, or leukocytosis). Patients were excluded if they had received antibiotic therapy prior to hospital presentation, had hospital-acquired or ventilator-associated pneumonia, or if the pneumonia was considered aspiration-related. Immunocompromised patients (e.g., those with Human Immunodeficiency virus/ Acquired Immunodeficiency Syndrome, receiving chemotherapy, or on chronic immunosuppressive therapy) were also excluded to maintain homogeneity of the study population.

Sample size calculation

The minimum required sample size was calculated using the formula: n = 4pq/dZ, where *p* represents the estimated prevalence of community-acquired pneumonia in adults (assumed to be 8%), *q = 1 – p*, and *d* represents the desired margin of error (5%). Using this formula, the sample size was determined to be 117 patients.

Patient enrollment and data collection

Patients were enrolled consecutively upon presentation to the emergency department or medical outpatient services. A structured clinical proforma was used to systematically collect demographic data (age, sex, smoking status, occupation), clinical history (symptom onset and duration, fever pattern, sputum characteristics, comorbid conditions), physical findings (vital signs, auscultation, oxygen saturation), and radiological interpretations. All data were collected by trained resident physicians and verified by attending consultants.

Radiological Assessment

All patients underwent a posteroanterior chest radiograph on admission. Imaging was interpreted by two independent radiologists, blinded to microbiological results. In cases with equivocal findings or suspected complications such as empyema, cavitation, or multilobar involvement, a high-resolution computed tomography (HRCT) scan of the thorax was performed to confirm diagnosis.

Microbiological investigations

Sputum collection and processing

In this study, sputum samples were meticulously processed to isolate and identify causative pathogens of CAP through a standardized microbiological approach. Sputum, collected aseptically from patients prior to antibiotic administration, was inoculated onto three distinct culture media: blood agar, chocolate agar, and MacConkey agar. Blood agar, a nutrient-rich medium supplemented with 5-10% defibrinated sheep or horse blood, supports the growth of a

wide range of bacteria, including fastidious organisms, and allows for the observation of hemolytic patterns (e.g., alpha, beta, or gamma hemolysis) that aid in preliminary identification. Chocolate agar, prepared by heating blood agar to lyse erythrocytes and release additional nutrients like hemin and Nicotinamide Adenine Dinucleotide (NAD), was employed to cultivate more demanding pathogens, such as *Haemophilus influenzae* or other fastidious gram-negative species, which might not grow well on standard media. MacConkey agar, a selective and differential medium containing bile salts and crystal violet, was used to inhibit gram-positive bacteria and promote the growth of gram-negative organisms, while differentiating lactose fermenters (e.g., *Klebsiella pneumoniae*, appearing as pink colonies) from non-fermenters (e.g., *Pseudomonas species.*, appearing as colourless colonies). These inoculated plates were incubated at 37°C, mimicking human body temperature, for 24 to 48 hours in an aerobic environment, with periodic inspection to detect colony growth. This incubation duration allowed sufficient time for slower-growing pathogens to emerge while minimizing overgrowth by contaminants, ensuring reliable isolation of clinically relevant bacteria.

Concurrently, blood samples were cultured to detect bacteraemia, a critical complication in severe CAP cases. Approximately 10 mL of venous blood, drawn aseptically from each patient, was inoculated into specialized culture bottles designed for an automated blood culture system, such as the Becton Dickinson Automated Blood Culture System (BACTEC) system. This system utilizes a broth medium enriched with nutrients (e.g., tryptic soy broth) and anticoagulants, often supplemented with resins or charcoal to neutralize antibiotics or other inhibitory substances present in the blood [7]. The bottles were incubated at 37°C for up to 5 days within the automated system, which continuously monitors for microbial growth by detecting metabolic byproducts, such as carbon dioxide, through fluorescence or colorimetric changes. This extended incubation period enhances the detection of slow-growing or fastidious organisms, including anaerobes or facultative anaerobes like *Streptococcus pneumoniae* or *Klebsiella pneumoniae*, which may require longer to reach detectable levels. Positive cultures signalled by the system were promptly sub-cultured onto appropriate agar plates (e.g., blood or MacConkey agar) for further isolation and identification, ensuring a comprehensive assessment of systemic infection in CAP patients.

Following isolation, bacterial colonies isolate from both sputum and blood cultures were identified using a battery of biochemical tests tailored to differentiate species based on their metabolic and enzymatic properties. These tests included standard assays such as catalase (to distinguish staphylococci from streptococci), oxidase (to identify *Pseudomonas* and related species), and indole production (to confirm *Escherichia coli*). For gram-negative bacilli, additional tests like the triple sugar iron agar (TSI) reaction, urease production (positive in

Klebsiella), and motility assays were employed, while gram-positive organisms were assessed with tests like coagulase (for *Staphylococcus aureus*) and optochin susceptibility (for *S. pneumoniae*). These manual methods, grounded in classical microbiology, allowed precise species-level identification, leveraging characteristic biochemical profiles established in clinical laboratory standards. The process was conducted in a controlled laboratory environment to minimize contamination and ensure accuracy, with results cross-checked against reference standards for reliability.

Antimicrobial susceptibility testing

Antibiotic susceptibility of the isolates was determined by the Kirby–Bauer disk diffusion method on Mueller–Hinton agar plates following Clinical and Laboratory standards institute (CLSI) 2020 guidelines [8,9]. Bacterial suspensions were prepared to a turbidity equivalent to 0.5 McFarland standard (~1.5×10^8 Colony-Forming unit/mL). Antibiotic disks tested included meropenem, ertapenem, amikacin, ceftriaxone, cefuroxime, and others as per institutional antibiograms. Plates were incubated at 37°C for 16–18 hours. Zone diameters were measured in millimetres using callipers and interpreted according to CLSI breakpoint charts. Internal quality control was maintained using *Escherichia coli*-American Type Culture Collection (ATCC)-25922 and *Staphylococcus aureus*-ATCC-25923.

Study variables and outcomes

The primary outcome was the identification of causative bacterial pathogens in patients with CAP and their in vitro antibiotic susceptibility patterns. Secondary outcomes included the distribution of CAP by demographic factors, clinical presentation, and presence of comorbid conditions.

a. *Independent variables:* Age, sex
b. *Potential confounders:* Comorbidities including hypertension, diabetes, chronic obstructive pulmonary disease (COPD), bronchiectasis, and interstitial lung disease
c. *Outcome variables:* Bacteriological profile, resistance patterns, and clinical features

Statistical analysis

Data were entered into Microsoft Excel and analyzed using IBM SPSS Statistics for Windows, Version 27.0 (IBM Corp., Armonk, NY) and GraphPad Prism, Version 5.0. Continuous variables were expressed as mean ± standard deviation (SD), and categorical variables as frequencies and percentages.

Associations between categorical variables were evaluated using the chi-square test or Fisher's exact test, as appropriate.

Comparisons between continuous variables were made using the independent samples t-test. A p-value <0.05 was considered statistically significant.

Literature review

To support the rationale and contextualize findings, a comprehensive literature search was conducted using databases including PubMed, Google Scholar, and the Cochrane Library. Search terms included "community-acquired pneumonia," "bacteriology," "antibiotic resistance," and "India." Articles published in English from the last 10 years were prioritized. References were compiled using Zotero and formatted in Vancouver style.

Results

Demography

Among 117 enrolled participants, 90 (76.9%) were male and 27 (23.1%) were female. The mean age was 52 ± 18.06 years.

The 31–40 age group was most common overall (19.7%, n=23) and among males (21.1%, n=19), while the 71–80 year age group was most common among females (22.2%, n=6). Common comorbidities were hypertension (22.2%, n=26), COPD (21.3%, n=25), smoking (19.7%, n=23), and Type 2 Diabetes Mellitus (T2DM; 15.3%, n=18). One patient was immunocompromised; one had chronic hepatitis C (Table 1).

Clinical features

The most common symptom was cough (70.9%, n=83), with 48 (41.0%) reporting productive cough, followed by shortness of breath (61.5%, n=72) and fever (44.4%, n=52). Less frequent symptoms included haemoptysis (7.0%, n=8), chest pain (7.0%, n=8), altered sensorium (2.0%, n=2), abdominal pain (2.0%, n=2), vomiting (2.0%, n=2), and weakness (2.0%, n=2). Radiologically, 93 patients (79.4%) showed consolidation, 25 (21.4%) had pleural effusion, and 11 (9.4%) had normal chest X-rays.

Sputum culture and bacteriological profile

Sputum cultures were positive in 42.7% (n=50) of 117 patients. Gram-negative organisms predominated (94.0%, n=47), with *Klebsiella pneumoniae* being most common (44.0%, n=22), followed by *Pseudomonas species.* (20.0%, n=10). Gram-positive isolates comprised 6.0% (n=3), including Methicillin resistant staphylococcus aureus (MRSA; 4.0%, n=2) and Methicillin sensitive staphylococcus aureus (MSSA; 2.0%, n=1) (Figure 1).

Antibiotic sensitivity

Among 47 gram-negative isolates, sensitivity was highest for meropenem (95.7%, n=42/44 tested), amikacin (92.7%, n=38/41), and ertapenem (90.0%, n=27/30), and lowest for cefuroxime (9.3%, n=4/43) and ceftriaxone (14.9%, n=7/47). Amoxicillin sensitivity was 41.7% (n=10/24) (Table 2).

Discussion

Demographic and clinical characteristics

In this cross-sectional study of 117 patients with CAP at the North-Eastern India, we observed a mean age of 52 ± 18.06 years, with a distinctive bimodal age distribution. The 31–40 age group was most common overall (19.7%, n=23) and among males (21.1%, n=19), followed by the 61–70 age group in males (17.8%, n=16), while females peaked at 71–80 years (22.2%, n=6). This younger peak contrasts with findings from *Mahendra et al.* in Karnataka (mean age, 54.03 years; 66% males), *Para et al* in Kashmir (median age, 59 years), *Shah et al.* in Srinagar (mean age, 53.68 ± 14.74 years; 60–69 years predominant), and *Kalita et al.*in northeastern India (mean age, 57.2 ± 17.2 years; peak >60 years), where older adults were more affected [10-13]. *Kanishan et al*. in Mangalore (>55 years) and *Menon et al*. in Kerala (51–60 years) also reported older peaks, suggesting that the prominence of younger adults in our cohort may reflect unique regional exposures or early comorbidity onset [14,15]. Hypertension (22.2%, n=26), COPD (21.3%, n=25), and smoking (19.7%, n=23) were the leading risk factors, followed by diabetes mellitus (15.3%, n=18), coronary artery disease (8.5%, n=10), chronic liver disease (6.8%, n=8), and chronic kidney disease (2.5%, n=3). Compared with higher rates in *Para et al*. (hypertension, 77.3%; COPD, 70.5%; diabetes, 30.2%) and *Shah et al*. (smoking, 65%; COPD, 57%), our comorbidity burden is moderate, though smoking aligns with *Kalita et al*.(52.1%) as a key regional risk [11-13].

Symptom profile

Clinically, cough was the most frequent symptom (70.9%, n=83; 41.0% productive, n=48), followed by shortness of breath (61.5%, n=72) and fever (44.4%, n=52). Less common were hemoptysis and chest pain (each 7.0%, n=8), with altered sensorium, abdominal pain, vomiting, and weakness each at 2.0% (n=2). This contrasts with *Kalita et al.*, where fever led (88.5%), followed by cough (82.4%) and shortness of breath (53.3%), and Shah et al., reporting near-universal fever and cough (99%) [13]. *Para et al*. noted cough (89.8%) and breathlessness (69.3%), while *Abdullah BB et al*. found cough (74%), fever (56%), and dyspnea (22%) [11,16]. The lower fever rate in our study versus these reports may suggest delayed presentation or host immunosuppression, while the high dyspnea prevalence, akin to Para et al., may reflect severe

disease or gram-negative pathogen impact [10]. This variability underscores the need for region-specific clinical assessment, as symptom patterns deviate from typical CAP presentations elsewhere.

Microbiological findings and antibiotic sensitivity

Sputum cultures identified *Klebsiella pneumoniae* as the predominant pathogen (44.0%, n=22), followed by *Pseudomonas species.* (20.0%, n=10), *Escherichia coli* (14.0%, n=7), and *Acinetobacter species.* (14.0%, n=7), a gram-negative profile diverging from the global dominance of *Streptococcus pneumoniae* seen in North India (30.5%) and Shimla (35.8%). Regional parallels exist with *Sharma et al*. in Pune (*Klebsiella*, 21.7%), *Prasad et al*. in Mangalore (*Klebsiella*, 20.9%; *Pseudomonas*, 18.8%), and *Kalita et al*.(*Klebsiella*, 31.6%; *S. pneumoniae*, 31%), though our study shows a stronger gram-negative skew [13,17-20]. *Peto et al.*'s Asian review reported gram-negative bacilli in 13% of CAP cases, rising to 21.5% in severe cases, aligning with our findings as indicative of severe presentations [21]. Antibiotic sensitivity testing showed gram-negative isolates highly responsive to meropenem (95.7%, n=42/44), amikacin (92.7%, n=38/41), and ertapenem (90.0%, n=27/30), but resistant to cefuroxime (9.3%, n=4/43) and ceftriaxone (14.9%, n=7/47). This resistance, likely mediated by beta-lactamases, mirrors Indian trends and highlights the inadequacy of commonly used empirical regimens in this setting [22].

Implications

The predominance of gram-negative pathogens challenges conventional CAP diagnostics reliant on *S. pneumoniae*, necessitating localized strategies to improve diagnostic accuracy and treatment timeliness. With males and age extremes most affected, and hypertension and COPD prevalent, clinicians can enhance risk stratification for early intervention [23]. The efficacy of carbapenems and aminoglycosides over cephalosporins supports their use in severe cases, urging the development of local antibiograms and guidelines to optimize empirical therapy and curb resistance escalation.

Significance and probable mechanism

These findings are critical because they reveal a regionally distinct CAP etiology that deviates from global norms, potentially affecting morbidity and mortality if standard protocols are applied without adaptation, and they highlight an alarming resistance to commonly used antibiotics, threatening treatment efficacy in a resource-limited setting. The most probable mechanism driving this gram-negative dominance and resistance involves the interplay of northeastern India's humid climate, which likely enhances the environmental persistence and

mucosal colonization of bacilli like *Klebsiella pneumoniae*, with host factors such as smoking and COPD compromising pulmonary clearance mechanisms [24,25]. Widespread cephalosporin misuse, facilitated by over-the-counter availability, may exert selective pressure, fostering resistance through enzymatic degradation by extended-spectrum beta-lactamases or AmpC beta-lactamases, while delayed healthcare access and socioeconomic factors like overcrowding amplify the spread of resistant strains, creating a unique regional pathology that demands targeted investigation and response [24,25].

Limitations and future directions

This study, conducted at a single tertiary care centre, primarily captured severe CAP cases, potentially overrepresenting gram-negative pathogens and underrepresenting milder presentations. The cross-sectional design, limited to one year, may not account for seasonal variations in etiology or resistance trends, while the sample size (n=117), though calculated for prevalence, lacks power to detect rare pathogens or subtle subgroup differences. The absence of minimum inhibitory concentration (MIC) data, due to limited laboratory resources, restricts precise assessment of antibiotic resistance severity, relying instead on standard disk diffusion susceptibility testing. Limited access to molecular diagnostics, such as polymerase chain reaction (PCR) for atypical pathogens or viruses, likely underestimates their contribution, focusing results on culturable bacteria. Consecutive sampling at one site may introduce selection bias, limiting generalizability to other northeastern Indian settings.

Multicentre, longitudinal studies with larger, diverse cohorts are needed to validate these findings, capture temporal trends, and enhance applicability across the region. Incorporating advanced diagnostics like PCR for atypical bacteria and viruses, alongside molecular analyses of resistance genes (e.g., Extended spectrum beta lactamase and carbapenems), would provide a fuller etiologic picture and clarify resistance mechanisms. Such efforts could refine therapeutic strategies, inform region-specific guidelines, and guide public health interventions to address the evolving challenge of CAP in northeastern India.

Conclusions

This study found CAP to be more prevalent in males and at extremes of age, particularly 31– 40 and over 70 years. Hypertension, smoking, and COPD emerged as the most common risk factors. Gram-negative bacilli, notably *Klebsiella pneumoniae*, were the predominant etiological agents, differing from global patterns favouring *Streptococcus pneumoniae*. Antibiotics such as meropenem, amikacin and ertapenem demonstrated the highest sensitivity against these isolates, while recommended empirical antibiotics like ceftriaxone and cefuroxime showed significant drug resistance. These findings highlight the need for region-

specific treatment guidelines in northeastern India to address local pathogen profiles and resistance patterns.

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Table 1. Age, sex, and comorbidities distribution.

Category	Subcategory	Frequency (n)	Percentage (%)
Sex	Male	90	76.9
	Female	27	23.1
Age group (years)	30	17	14.5
	31-40	23	19.7
	41-50	17	14.5
	51-60	17	14.5
	61-70	21	17.9
	71-80	19	16.2
	81-90	3	2.6
Comorbidities/risk factors	Smoking	23	19.7
	COPD	25	21.3
	CAD	10	8.5
	CKD	3	2.5
	CLD	8	6.8
	T2DM	18	15.3
	Hypertension	26	22.2
Total		**117**	**100.0**

COPD, chronic obstructive pulmonary disease; CAD, coronary artery disease; CKD, chronic kidney disease; CLD, chronic liver disease; T2DM, type 2 diabetes mellitus.

Table 2. Antibiotic sensitivity of Gram-negative isolates.

Antibiotic	Sensitive (n)	Tested (n)	Percentage (%)
Amoxicillin	10	24	41.7
Amoxicillin-Clavulanate	17	36	47.2
Ceftriaxone	7	47	14.9
Cefuroxime	4	43	9.3
Ciprofloxacin	30	35	85.7
Amikacin	38	41	92.7
Meropenem	42	44	95.7
Ertapenem	27	30	90.0
Piperacillin-Tazobactam	37	48	77.1

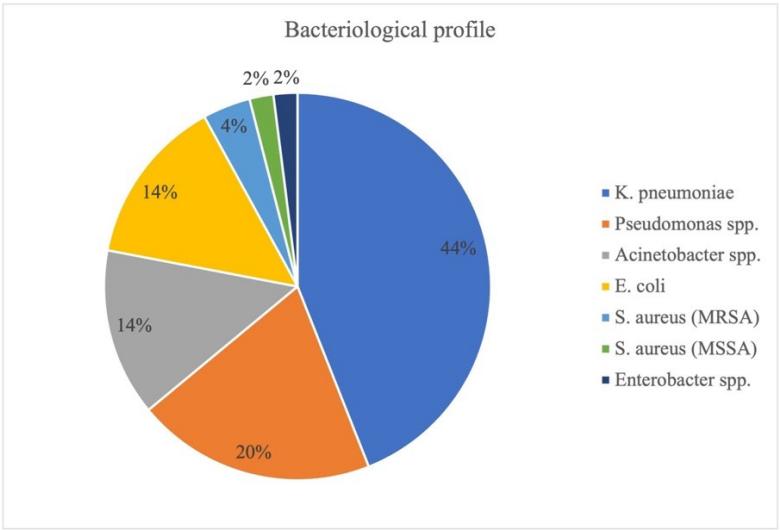

Figure 1. Pie chart showing bacteriological profile of the study population.