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# Clinical, Epidemiological, and Microbiological Profile of Community-Acquired Pneumonia: A Cross-Sectional Study

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## ABSTRACT

**Background:** Community-acquired pneumonia (CAP) is a significant cause of illness and death around the world, especially in low- and middle-income countries. Its clinical features and the pathogens that cause it can differ by region. These differences are affected by existing health conditions and local resistance patterns. Knowing these factors is crucial for developing effective diagnosis and treatment methods.

**Objective:** To assess the clinical presentation, epidemiological characteristics, and microbiological etiology of patients diagnosed with community-acquired pneumonia.

**Methodology:** This study took place at a tertiary care hospital and involved 160 adult patients diagnosed with community-acquired pneumonia. We recorded detailed clinical histories, comorbidities, and radiological findings. Sputum samples were collected for bacterial culture and sensitivity testing using standard microbiological methods. We interpreted antimicrobial susceptibility following Clinical and Laboratory Standards Institute (CLSI) guidelines to identify resistance patterns.

**Results:** Out of 160 patients, 76% were male. The most affected age groups were 31 to 40 years and 61 to 70 years. Common other health issues included hypertension at 23.8%, smoking at 21.8%, COPD at 20%, and diabetes at 18.7%. Sputum cultures tested positive in 45% of cases. The leading pathogens were Klebsiella pneumoniae at 44% and Pseudomonas spp. at 22%. There was high resistance to ceftriaxone at 83%.

**Conclusion:** The study showed a heavy impact of CAP in middle-aged and older men with common health issues like hypertension and COPD. Gram-negative bacteria, especially Klebsiella pneumoniae and Pseudomonas spp., were the main pathogens. High resistance to cephalosporins restricts their use.

**Keywords:** Community-Acquired Pneumonia; CLSI; Bacteria; Antibiotics

## Introduction

Community-acquired pneumonia (CAP) is one of the most common and serious infectious diseases worldwide. It significantly affects illness rates, hospital stays, and death rates, especially among older adults and people with chronic conditions. Globally, CAP occurs in 1 to 14 cases per 1,000 person-years. Higher rates are seen in older populations and those with existing health issues. In the United States, CAP causes more than 1.4 million visits to emergency departments and over 700,000 hospital admissions each year. The death rate is particularly high for individuals aged 65 and older, often exceeding 20% in hospitalized cases.[1-3]

Several host-related risk factors can make individuals more likely to develop CAP. These factors include older age, being male, smoking, and chronic respiratory issues like chronic obstructive pulmonary disease (COPD).[3] Other conditions such as diabetes, heart disease, and chronic kidney or liver disease also play a role.[4] These health issues weaken lung defenses and immune responses, making it easier for respiratory germs to cause infections.[5]

Historically, Streptococcus pneumoniae has been the top bacterial cause of community-acquired pneumonia (CAP) worldwide. Recent evidence indicates significant changes in the types of bacteria responsible, largely due to better vaccination coverage, changes in antibiotic prescribing, and improved diagnostic methods. In many developing and middle-income countries, gram-negative bacilli like Klebsiella pneumoniae, Pseudomonas aeruginosa, and Acinetobacter species have become major pathogens.[2,3,6] This is especially true for patients with certain risk factors. A study from Tanzania showed that gram-negative organisms were responsible for over 80% of culture-positive CAP cases in adults, with Klebsiella and Pseudomonas species being the most frequently found.[7]

An additional concern in managing CAP is the growing trend of antimicrobial resistance, especially among gram-negative organisms. Multidrug-resistant (MDR) Enterobacteriaceae, including extended-spectrum beta-lactamase (ESBL) and carbapenemase-producing strains, are becoming more common in clinical settings, especially in South Asian countries. A recent meta-analysis from Pakistan found carbapenem resistance rates over 20% in Klebsiella pneumoniae isolates, with New Delhi metallo-β-lactamase (NDM) present in a significant number of strains.[4] Similar resistance trends are seen globally, with Acinetobacter baumannii exhibiting resistance rates above 40% to imipenem and over 50% to meropenem. This situation limits treatment options and increases reliance on toxic agents like colistin.[8]

While international guidelines from the Infectious Diseases Society of America (IDSA) and the American Thoracic Society (ATS) provide treatment recommendations for community-acquired pneumonia (CAP) based on severity and other health issues, these often come from data collected in wealthy countries.[5,9] Their relevance in low- and middle-income countries (LMICs) is increasingly questioned because of different pathogen types and resistance patterns. In LMICs, doctors often start treatment without confirming the cause due to limited access to diagnostic tests. They must depend on local antibiograms and resistance information to guide their therapy.[6,7]

In South Asia, including Pakistan, there is a lack of detailed data on the clinical, microbial, and resistance profiles of patients with community-acquired pneumonia. Existing studies indicate a predominance of gram-negative organisms and high levels of resistance to commonly used antibiotics like ceftriaxone, cefuroxime, and fluoroquinolones. As a result, there is a growing dependence on carbapenems and aminoglycosides, raising concerns about future antibiotic management and the development of resistance.[4,8]

Considering the changing microbial environment and increasing antimicrobial resistance, particularly with gram-negative bacteria, there is an urgent need to gather local data on the clinical, epidemiological, and microbiological traits of community-acquired pneumonia (CAP). Understanding how pathogens are distributed, and their resistance patterns is essential for improving treatment, lowering failures, and enhancing patient outcomes. This study aimed to examine clinical presentation, risk factors, microbiological causes, and antibiotic susceptibility patterns of CAP in a group of 160 patients in our area.

## Objective

To assess the clinical presentation, epidemiological characteristics, and microbiological etiology of patients diagnosed with community-acquired pneumonia.

## Methodology

This was a prospective, cross-sectional, observational study conducted in the Department of Medicine, Mardan Medical Complex, Mardan – Pakistan. The study was carried out over a period of six months. Ethical approval was obtained from the Institutional Review Board, MMC Mardan and written informed consent was secured from all participants prior to enrollment.

The study included adult patients aged 18 years and above who presented with signs and symptoms consistent with community-acquired pneumonia (CAP), such as cough, fever, sputum production, chest pain, or shortness of breath. A diagnosis of CAP was confirmed by the presence of new infiltrates on chest radiograph or high-resolution computed tomography (HRCT), in conjunction with clinical features suggestive of lower respiratory tract infection. Patients who had received antibiotics within 72 hours prior to presentation were excluded to minimize false-negative culture results. Other exclusion criteria included hospital-acquired or ventilator-associated pneumonia, known cases of aspiration pneumonia, active pulmonary tuberculosis, and patients with immunosuppressive conditions such as HIV/AIDS, malignancy on chemotherapy, or organ transplantation.

The sample size was calculated using the formula for prevalence studies, assuming a bacterial culture positivity rate of 50%, a 95% confidence level (Z = 1.96), and a margin of error of 8%. Based on this, the minimum required sample was 150 patients; however, to improve reliability and enable subgroup analysis, 160 patients were ultimately enrolled consecutively during the study period.

Data were collected using a structured proforma and included patient demographics (age, sex, occupation), clinical history (onset and duration of symptoms, fever pattern, cough type, breathlessness, hemoptysis), comorbidities (e.g., COPD, diabetes, hypertension), vital signs on presentation, and physical examination findings. Laboratory investigations such as complete blood count, renal and liver function tests, and arterial blood gases were also recorded where applicable. All patients underwent chest radiography on admission, and HRCT was performed when the chest X-ray was inconclusive or when complications such as multilobar consolidation, effusion, or cavitation were suspected.

Microbiological evaluation included both sputum and blood cultures. Sputum specimens were collected in sterile containers prior to the initiation of antibiotic therapy. Samples were accepted for processing only if they showed <10 squamous epithelial cells and >25 polymorphonuclear leukocytes per low-power field, indicating minimal contamination. The specimens were promptly inoculated on blood agar, chocolate agar, and MacConkey agar, and incubated at 37°C for 24–48 hours. Identification of isolates was carried out using standard biochemical tests, including catalase, oxidase, triple sugar iron (TSI) slants, citrate utilization, indole, and urease testing, depending on the gram staining results and colony morphology.

Blood cultures were obtained from patients presenting with systemic signs such as high-grade fever, chills, or hypotension. Aseptic technique was used to collect 10 mL of venous blood, which was inoculated into commercially available automated blood culture bottles (e.g., BACTEC system) and incubated for up to five days. Positive samples were sub-cultured and processed using the same identification techniques as sputum isolates.

Antimicrobial susceptibility testing was performed using the Kirby-Bauer disk diffusion method on Mueller-Hinton agar, following the Clinical and Laboratory Standards Institute (CLSI) 2020 guidelines. Antibiotic discs used included amoxicillin-clavulanate, ceftriaxone, cefuroxime, ciprofloxacin, piperacillin-tazobactam, amikacin, ertapenem, and meropenem. After incubation for 18–24 hours, inhibition zone diameters were measured and interpreted according to CLSI breakpoints. Internal quality control was maintained using standard ATCC strains, including Escherichia coli ATCC 25922 and Staphylococcus aureus ATCC 25923.

The primary outcome of the study was the identification of bacterial pathogens responsible for CAP and their antibiotic resistance patterns. Secondary outcomes included an analysis of patient demographics, symptomatology, comorbidity profiles, and radiological findings. All collected data were entered into Microsoft Excel and analyzed using IBM SPSS version 27.0. Continuous variables such as age were expressed as mean ± standard deviation, whereas categorical variables were presented as frequencies and percentages. Associations between categorical variables were assessed using the chi-square test or Fisher's exact test, as appropriate. A p-value of less than 0.05 was considered statistically significant.

## Results

A total of 160 patients with community-acquired pneumonia (CAP) were included in the present study. The cohort consisted of 122 males (76.3%) and 38 females (23.7%), with a mean age of 53.4 ± 17.6 years.

The most frequently affected age group was 31–40 years (20.0%), followed by 61–70 years (18.8%). The distribution of patients by age and sex is presented in Table 1.

The most prevalent comorbidities among the study cases were Hypertension (23.8%), chronic obstructive pulmonary disease (COPD, 22.5%), and a history of smoking (21.3%). Type 2 diabetes mellitus (T2DM) was reported in 18.8% of patients. Less common conditions included coronary artery disease (7.5%), chronic liver disease (5.6%), and chronic kidney disease (3.1%). The distribution of comorbidities is shown in Table 2.

The most common clinical symptom was a cough, reported in 126 patients (78.8%). Among these, 72 patients (45%) had productive sputum. Other common symptoms included shortness of breath (61.3%, n = 98) and fever (51.3%, n = 82). Chest pain (8.8%), hemoptysis (6.3%), altered mental status, and gastrointestinal symptoms were less common.

Radiological assessment showed lung consolidation in 130 patients (81.3%), while 36 patients (22.5%) had pleural effusion. Interestingly, 14 patients (8.8%) had normal chest X-rays at presentation. High-resolution computed tomography (HRCT) was done in 46 patients (28.8%) for further evaluation in selected cases.

Sputum cultures were positive in 72 patients (45%). Among culture-positive cases, gram-negative organisms accounted for 91.7% (n = 66), while gram-positive

Table 1. Age and sex distribution among CAP patients (n = 160)

| Age group (years) | Male (n) | Female (n) | Total (n) | Percentage (%) |
|---|---|---|---|---|
| 18–30 | 15 | 4 | 19 | 11.9 |
| 31–40 | 26 | 6 | 32 | 20.0 |
| 41–50 | 20 | 4 | 24 | 15.0 |
| 51–60 | 18 | 6 | 24 | 15.0 |
| 61–70 | 22 | 8 | 30 | 18.8 |
| 71–80 | 15 | 8 | 23 | 14.4 |
| >80 | 6 | 2 | 8 | 5.0 |
| Total | 122 | 38 | 160 | 100.0 |

organisms were detected in 8.3% (n = 6). The most isolated pathogen was Klebsiella pneumoniae (n = 32, 44.4%), followed by Pseudomonas spp. (n = 16, 22.2%), Escherichia coli (n = 10, 13.9%), and Acinetobacter spp. (n = 8, 11.1%). Among gram-positive isolates, methicillin-resistant Staphylococcus aureus (MRSA) was found in 4 patients (5.6%), and methicillin-sensitive S. aureus (MSSA) in 2 patients (2.8%) (Figure 2).

Antimicrobial susceptibility testing of gram-negative isolates (n = 66) showed the highest sensitivity to meropenem at 95.4%. This was followed by amikacin at 93.8% and ertapenem at 88.9%. Piperacillin-tazobactam had a sensitivity of 78.5%. Moderate sensitivity was seen for ciprofloxacin at 75.4%. Cephalosporins were less effective, with ceftriaxone and cefuroxime showing sensitivity of only 16.7% and 10.6%, respectively. Amoxicillin-clavulanate had intermediate sensitivity at 45.5% (Table 3).

## Discussion

Community-acquired pneumonia (CAP) remains a major cause of illness and death worldwide. This issue is especially serious in low- and middle-income countries due to delayed diagnosis, existing health conditions, and limited access to lab tests. The clinical and microbiological aspects of CAP are changing, shaped by regional differences in the types of germs present, patterns of resistance to antibiotics, and healthcare practices. This study aimed to evaluate the clinical presentation, existing health conditions, bacterial causes, and antibiotic resistance patterns in patients with CAP who were

Table 2. Comorbidities and risk factors (n = 160)

| Comorbidity/Risk Factor | Frequency (n) | Percentage (%) |
|---|---|---|
| Hypertension | 38 | 23.8 |
| COPD | 36 | 22.5 |
| Smoking | 34 | 21.3 |
| T2DM | 30 | 18.8 |
| Coronary artery disease | 12 | 7.5 |
| Chronic liver disease | 9 | 5.6 |
| Chronic kidney disease | 5 | 3.1 |

Table 3. Antibiotic sensitivity pattern of gram-negative isolates (n = 66)

| Antibiotic | Sensitive (n) | Tested (n) | Sensitivity (%) |
|---|---|---|---|
| Meropenem | 63 | 66 | 95.4 |
| Amikacin | 62 | 66 | 93.8 |
| Ertapenem | 56 | 63 | 88.9 |
| Piperacillin–Tazobactam | 52 | 66 | 78.5 |
| Ciprofloxacin | 49 | 65 | 75.4 |
| Amoxicillin–Clavulanate | 30 | 66 | 45.5 |
| Ceftriaxone | 11 | 66 | 16.7 |
| Cefuroxime | 7 | 66 | 10.6 |

admitted to a tertiary care hospital. The findings provide valuable insights into the current state of CAP in our area and offer crucial comparisons with studies from other regions. In the following discussion, we will interpret our findings alongside existing research, pointing out both similarities and differences, and exploring their implications for clinical care and public health policy.

In our group of 160 patients with community-acquired pneumonia (CAP), the demographic and comorbidity findings reflect known global patterns. The male predominance is 76%, and the most affected age groups are 31–40 years and 61–70 years. These observations match what we see in similar settings. A systematic review from India reported COPD in 24.2%, hypertension in 23.7%, diabetes in 16%, and a high prevalence of older age and smoking, closely aligning with our cohort.[11] Likewise, a Japanese epidemiologic study found chronic pulmonary disease (21%), malignancy (24%), and heart

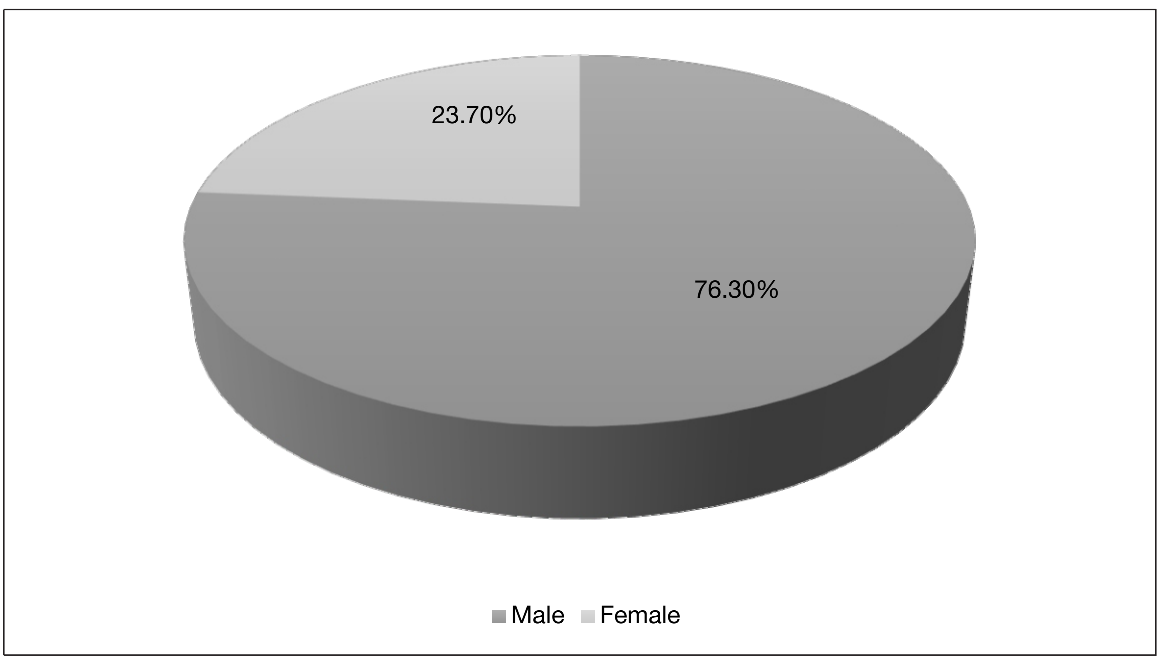


Figure 1. Gender Base distribution of study cases

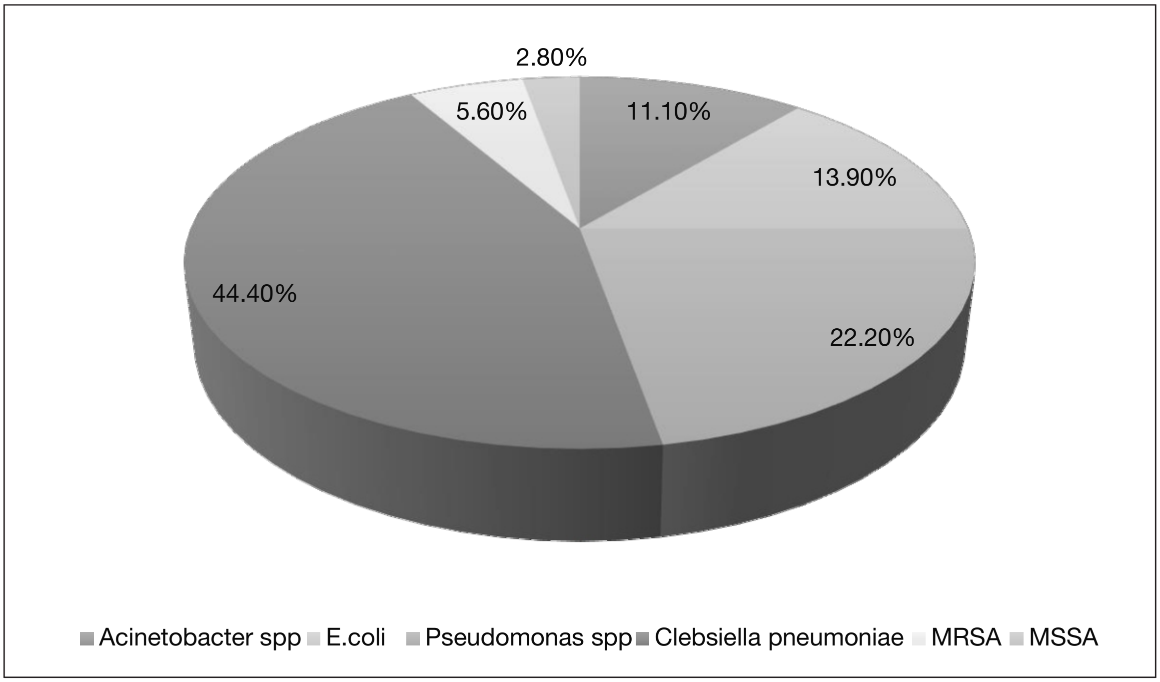


Figure 2. Distribution of pathogens isolated from sputum cultures.

failure (19%) as common comorbidities linked to increased CAP mortality.[12] Additionally, data from Nigeria showed that hypertension (24.5%), diabetes (10.8%), and COPD (6.9%) are the most common accompanying illnesses.[13] These comparisons confirm that comorbidities like hypertension, COPD, smoking history, and diabetes are consistent risk markers across different regions and age groups.

Regarding clinical presentation and radiological features, our findings showed that cough (79%), dyspnea (61%), and fever (51%) were the most common symptoms. Radiological evidence of consolidation was present in 81% of patients, and pleural effusion occurred in 22.5%. These results match previous studies. For instance, research from Ilorin, Nigeria, reported that over 90% of patients had cough and dyspnea, and radiological consolidation was often observed.[13] Similarly, a cohort study from South Africa found that about 70 to 85% of hospitalized patients with CAP had consolidation on chest imaging, while pleural effusion happened in up to 25% of cases.[14] Although the exact distribution of symptoms varies between studies, the overall pattern consistently shows that CAP typically presents with clear respiratory complaints and specific radiographic findings. These comparisons highlight that, despite regional differences, the clinical and imaging features of CAP remain remarkably consistent across various settings.[15]

Our microbiological analysis showed a clear dominance of gram-negative bacteria, making up 92% of all culture-positive cases. The most commonly isolated pathogens were Klebsiella pneumoniae at 44%, followed by Pseudomonas species at 22%, Escherichia coli at 14%, and Acinetobacter species at 11%. In comparison, gram-positive organisms were quite rare, accounting for only 8% of the isolates. This pattern indicates a significant change in the microbial landscape of community-acquired pneumonia (CAP), particularly in our area. A study from Tanzania reported that gram-negative organisms comprised 83% of isolates in community-acquired pneumonia, with Klebsiella and Pseudomonas as the main pathogens. It also pointed out notable resistance to ceftriaxone.[7] Similarly, a hospital-based study from Northern India found that gram-negative bacteria were more common than Streptococcus pneumoniae, with Pseudomonas and Klebsiella leading among culture-positive cases.[6] Furthermore, a study in Srinagar, Kashmir, identified gram-negative bacilli, including Pseudomonas and E. coli, as the most frequent causes of CAP in their group.[16] These consistent results across different regions suggest a local shift in the causes of CAP—from the traditionally dominant pneumococcal infections to those caused mainly by gram-negative bacilli.

Our antibiotic susceptibility results highlight concern trends. Gram-negative bacteria showed high sensitivity to meropenem (95%), amikacin (94%), and ertapenem (89%). However, they displayed very low sensitivity to ceftriaxone (17%) and cefuroxime (11%), with moderate susceptibility to amoxicillin-clavulanate (45%). A study from Nigeria examined clinical isolates of Klebsiella pneumoniae and Pseudomonas aeruginosa. It found that imipenem and aminoglycosides remained effective, while resistance to third-generation cephalosporins like ceftriaxone and cefuroxime was strong.[13] Additionally, data from Addis Ababa, Ethiopia, indicated that carbapenem resistance in Acinetobacter spp. reached 61%. However, resistance to aminoglycosides was relatively less common. Resistance to extended-spectrum cephalosporins remained consistently high.[17] Overall, these findings support our observation that carbapenems and aminoglycosides are effective options in areas where cephalosporin resistance is widespread. They also highlight the declining usefulness of commonly used β-lactams in many regions.

These comparisons highlight important emerging trends in the epidemiology and antibiotic resistance of community-acquired pneumonia. First, conditions like chronic obstructive pulmonary disease (COPD), hypertension, diabetes, and tobacco use significantly increase patients' vulnerability to CAP across various populations. Second, the clinical presentation, which includes symptoms like cough, fever, and dyspnea, along with radiologic features like consolidation, remains largely consistent with what is typically described in the literature. Third, there seems to be a notable shift in many low- and middle-income countries (LMICs), with gram-negative organisms such as Klebsiella pneumoniae and Pseudomonas aeruginosa becoming the main pathogens, replacing the commonly seen Streptococcus pneumoniae. Finally, the growing resistance to widely used cephalosporins, especially ceftriaxone and cefuroxime, has reduced their effectiveness, while carbapenems and aminoglycosides continue to show better activity against these resistant strains. These patterns highlight the urgent need for treatment guidelines that are specific to each region and reflect the local microbial landscape and resistance profiles.

The high rates of hypertension, COPD, smoking history, and diabetes among our patients indicate a greater risk and severity that require careful prevention and management strategies. The prevalence of gram-negative pathogens and their resistance patterns suggest that empirical therapy based on international guidelines, like ATS/IDSA, may not be ideal in our situation if local antibiograms are ignored. Given the high resistance to ceftriaxone and cefuroxime, using these drugs as first-line treatment is questionable here. Carbapenems and aminoglycosides are effective, but they carry risks of toxicity and further resistance, highlighting the need for careful antibiotic use. Using local microbiological data in treatment plans is crucial to reduce treatment failures and prevent the development of resistance.

This study has a large sample size and follows standardized microbiological testing based on CLSI guidelines. The combined analysis of clinical features, other health conditions, radiologic data, and culture-based susceptibility increases its relevance. Limitations include a lack of molecular diagnostics for atypical and viral pathogens, which may lead to underestimating their occurrence, and its single-center design, which restricts how broadly the results can be applied.

## Conclusion

This study provides important insights into the clinical, epidemiological, and microbiological aspects of community-acquired pneumonia in our area. The presence of gram-negative pathogens, especially Klebsiella pneumoniae and Pseudomonas species, along with high resistance to third-generation cephalosporins, highlights the need for updated treatment strategies. Comorbidities like COPD, hypertension, diabetes, and smoking are significant risk factors that affect disease burden and outcomes. Our findings support improved local surveillance, tailored antibiotic use, and early diagnostic support to ensure more effective management of CAP.

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