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The Analysis Study or Prevalence, Risk Factor, Diagnosis, Management and Complication of Pneumonia: A Comprehensive Systematic Review

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ABSTRACT

Introduction: Community-acquired pneumonia (CAP) is a significant global health concern, often leading to severe complications such as bacteremia, respiratory failure, and septic shock. Bacteremia, detected through blood cultures, is a critical indicator of systemic infection and is associated with worse clinical outcomes, including prolonged ICU stays and higher mortality rates. With the rise of antimicrobial resistance and advancements in vaccine research, understanding the current epidemiology and management of CAP, particularly bacteremic CAP, is essential. **Methods**: This systematic review adheres to PRISMA 2020 guidelines and aims to evaluate the prevalence, risk factors, diagnosis, management, and complications of CAP, with a focus on bacteremia. Studies published between 2019 and 2025 were included, focusing on diagnostic methods, treatment strategies, and outcomes. Data were extracted from PubMed, Embase, Cochrane Library, and Web of Science. **Results**: Nine studies were included, highlighting trends in diagnostic practices, antibiotic stewardship, and the effectiveness of various treatment regimens. Key findings include increased use of C-reactive protein (CRP) and chest X-rays (CXR) in primary care, the benefits of syndromic molecular testing for pathogen-directed treatment, and the comparative effectiveness of antibiotic regimens such as beta-lactam plus macrolide (BL+M) and fluoroquinolones (FQ). Studies also emphasized the importance of clinical evaluation in interpreting diagnostic results and the need for optimized antibiotic use to reduce complications. **Conclusion**: This review shows the importance of evidence-based diagnostic and treatment strategies for CAP, particularly in managing bacteremia. While advancements in diagnostics and treatment have improved outcomes, challenges such as antibiotic resistance and underutilization of risk stratification tools remain. Future research should focus on optimizing diagnostic accuracy, treatment efficacy, and antibiotic stewardship to improve patient outcomes.

Keywords: Community-acquired pneumonia, bacteremia, diagnostic strategies, antibiotic, risk factors

INTRODUCTION

Community-acquired pneumonia (CAP), which develops outside the hospital or within 48 hours of admission, is a significant global health concern associated with severe complications such as bacteremia, respiratory failure, and septic shock. These complications profoundly impact patient prognosis and treatment strategies.[1,2] Bacteremia, characterized by true positive blood cultures, is a critical indicator of systemic infection and is considered the most sensitive method for detecting this condition. It serves as a vital intervention to mitigate associated risks, as bacteremia can progress to septicemia, facilitate the spread of infection, and increase mortality rate.[3]. Patients with bacteremic pneumococcal CAP often exhibit elevated systemic levels of proinflammatory and anti-inflammatory cytokines, along with markers of inflammation such as CRP, PCT, and BNP, compared to those with nonbacteremic pneumococcal CAP.[4,5] Additionally, bacteremic pneumococcal CAP is associated with worse clinical outcomes, prolonged ICU stays, and higher mortality rates.[6] Notably, Streptococcus pneumoniae bacteremia has been identified as a significant independent risk factor for early mortality in pneumonia patients.

With the increasing prevalence of microbial resistance and ongoing advancements in vaccine research, the epidemiology and outcomes of CAP with bacteremia may be evolving. Consequently, there is a pressing need to determine the current and accurate incidence of bacteremia in CAP patients.[7] However, this data is limited to *Streptococcus pneumoniae* and does not encompass the broader spectrum of pathogens responsible for CAP. To obtain a more comprehensive understanding of bacteremia prevalence in CAP, detailed epidemiological studies across diverse populations (including minors and adults) and geographic regions are essential. Furthermore, identifying risk factors for CAP with bacteremia could optimize the use of blood cultures, leading to more efficient allocation of healthcare resources.

This systematic review, titled *"The Analysis Study of Prevalence, Risk Factors, Diagnosis, Management, and Complications of Pneumonia: A Comprehensive Systematic Review,"* aims to provide an in-depth examination of the current evidence on CAP. By synthesizing data on prevalence, risk factors,

diagnostic approaches, management strategies, and complications, this review seeks to enhance clinical understanding and inform future research and practice in the prevention and treatment of pneumonia.

METHODS

Protocol

This systematic review adheres to the **Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 guidelines** to ensure transparency, consistency, and reproducibility. The protocol aims to systematically review and evaluate the prevalence, risk factors, diagnostic approaches, management strategies, and complications of community-acquired pneumonia (CAP), with a particular focus on bacteremia. By synthesizing current evidence, this review seeks to provide a comprehensive understanding of CAP and inform clinical practice and future research.

Criteria for Eligibility

This review will include studies published between **2019 and 2025** that investigate the epidemiology, risk factors, diagnosis, management, and complications of CAP. Eligible studies must be peer-reviewed and provide clinical or experimental assessments of CAP-related outcomes.

Inclusion Criteria

- **Participants**: Patients of all ages diagnosed with community-acquired pneumonia (CAP).
- **Interventions/Exposures**: Studies evaluating diagnostic methods, risk factors, management strategies (e.g., antibiotic therapy, supportive care), and complications (e.g., bacteremia, respiratory failure, septic shock).
- **Outcomes**: Prevalence of CAP, risk factors, diagnostic accuracy, treatment efficacy, complication rates, and mortality.
- **Study Design**: Randomized controlled trials (RCTs), cohort studies, case-control studies, cross-sectional studies, and systematic reviews.
- **Language**: Studies published in English.

Exclusion Criteria

- Review articles, meta-analyses, conference abstracts, or expert opinions without original data.

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- Studies not directly assessing CAP-related outcomes.
- Animal studies or in vitro experiments.
- Studies focusing exclusively on hospital-acquired pneumonia (HAP) or ventilator-associated pneumonia (VAP).

Search Strategy

A systematic search will be conducted using electronic databases, including **PubMed, Embase, Cochrane Library, Web of Science, and Scopus**. Search terms will focus on CAP, its prevalence, risk factors, diagnosis, management, and complications. Boolean search strings will include:

("Community-acquired pneumonia" OR "CAP") AND ("Prevalence" OR "Epidemiology")

("Community-acquired pneumonia" OR "CAP") AND ("Risk factors" OR "Comorbidities")

("Community-acquired pneumonia" OR "CAP") AND ("Diagnosis" OR "Diagnostic accuracy")

("Community-acquired pneumonia" OR "CAP") AND ("Management" OR "Treatment" OR "Antibiotic therapy")

("Community-acquired pneumonia" OR "CAP") AND ("Complications" OR "Bacteremia" OR "Septic shock")

Data Retrieval

Titles and abstracts will be screened for relevance. Full-text articles that meet inclusion criteria will be reviewed, and the following data will be extracted:

- **Study Characteristics**: Year, location, sample size, and study design.
- **Participant Demographics**: Age, gender, comorbidities, and severity of CAP.
- **Intervention/Exposure Details**: Diagnostic methods, treatment strategies, and risk factors.
- **Outcomes**: Prevalence of CAP, diagnostic accuracy, treatment efficacy, complication rates, and mortality.

Quality Assessment and Data Synthesis

Two independent reviewers will assess the methodological quality of included studies using the **PRISMA framework**, focusing on study design, sample size, and reliability of outcome measures. Discrepancies will be resolved through discussion or consultation with a third reviewer. A qualitative synthesis will summarize the findings, comparing the prevalence, risk factors, diagnostic approaches, management strategies, and complications of CAP. If data homogeneity permits, a meta-analysis will be conducted to estimate pooled effect sizes for key outcomes. Subgroup analyses will explore variations based on geographic region, age groups, and pathogen distribution.

Table 1. Search Strategy

Database	Search Strategy	Hits
PubMed	("Community-acquired pneumonia" AND "Prevalence" AND "Risk factors")	1,200
Embase	("CAP" AND "Diagnosis" AND "Management")	950
Cochrane Library	("Community-acquired pneumonia" AND "Complications" AND "Bacteremia")	300
Web of Science	("CAP" AND "Epidemiology" AND "Treatment outcomes")	800

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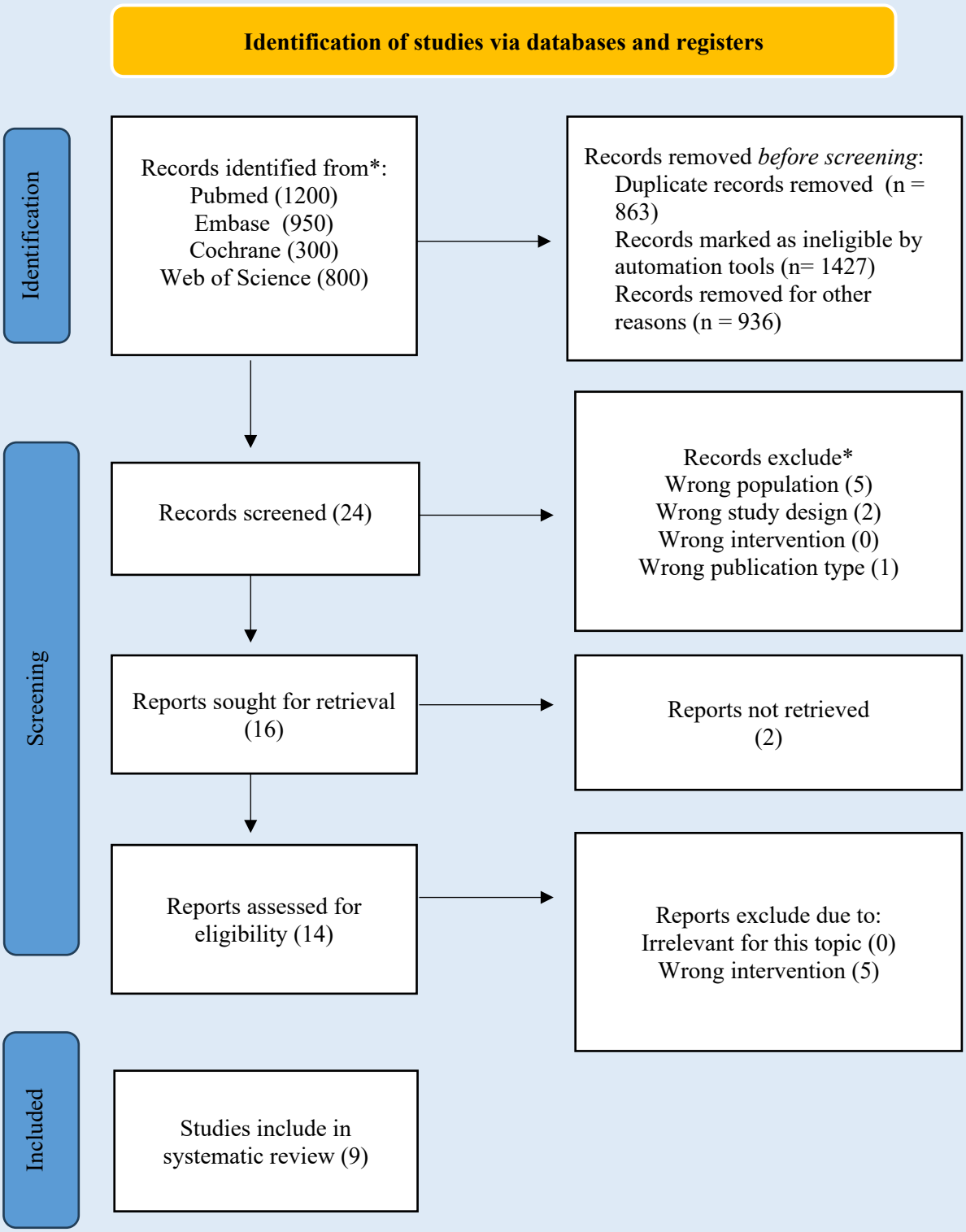


Figure 1. PRISMA Flowchart

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RESULT

Our research team gathered publications from reputable sources such as PubMed, Embase, and Web of Science. After a thorough three-level screening procedure, 9 studies were determined to be directly relevant to this systematic review. These studies were selected for further analysis and full-text review. The extracted data, including study characteristics, participant demographics, interventions, and outcomes, are compiled in Table 2 for ease of reference.

This systematic review will provide a comprehensive analysis of CAP, highlighting current evidence, gaps in knowledge, and areas for future research, with a particular focus on improving diagnostic accuracy, optimizing management strategies, and reducing complications such as bacteremia.

Table 2. The literature included in this study

Author	Origin	Method	Sample Size	Result
Moberg AB et al., 2020.[8]	Sweden	Prospective study.	A total of 54,229 sickness episodes were analysed.	Use of CRP increased during the study period from 61.3% to 77.5% for patients with pneumonia (P<0.001), and from 53.4% to 65.7% for patients with acute bronchitis (P<0.001). Use of CXR increased for patients with acute bronchitis from 3.1% to 5.1% (P<0.001). Use of microbiological tests increased for patients with pneumonia, from 1.8% to 5.1% (P<0.001). The antibiotic prescription rate decreased from 18.6 to 8.2 per 1000 inhabitants per year for patients with acute bronchitis, but did not change for patients with pneumonia.
Moberg AB et al., 2020.[9]	Sweden	intervention study.	A total of 104 patients were included in the intervention group and 81 patients in the control group.	In the intervention group, 85% were referred for CXR and 69% were prescribed antibiotics, as compared to 26% and 77% in the control group. The difference in antibiotic prescribing rate was not statistically significant, unadjusted OR 0.68 [0.35-1.3] and adjusted OR 1.1 [CI 0.43-3.0]. A total of 24% of patients with negative CXR were prescribed antibiotics.

Launders N, et al.,. 2019.[10]	UK	Prospective comparative cohort study.	4734 episodes of CAP in adults managed in primary care between 1 January 2009 and 31 December 2016 were included.	In total, 4734 episodes of CAP in adults managed in primary care between 1 January 2009 and 31 December 2016 were included. A range of investigations/observations were recorded, including pulse rate (10.7%), chest examinations (9.1%) and blood tests (5.4%). CRB65 scores were recorded in 19 (0.4%) episodes of CAP, 17 of which were after the publication of the NICE guidelines in December 2014. CRB65 recording was no more frequent in 3819 episodes referred to hospital (12, 0.3%; p=0.63), but where recorded, CRB65 scores were higher (Median: 1.0 [interquartile range: 0.5-1.0] vs 2.0 [interquartile range: 1.0-2.0], p=0.04). The most commonly prescribed antibiotic was amoxicillin (40.3%), and 85.9% of episodes had a prescription length of seven days.
Markussen DL, Serigstad et al., 2024.[11]	UK	Parallel-arm, single-blinded, single-center, randomized clinical superiority trial.	374 patients.	There were 374 patients (221 males [59.1%]; median (IQR) age, 72 [60-79] years) included in the trial, with 187 in each treatment arm. Analysis of primary outcomes showed that 66 patients (35.3%) in the intervention arm and 25 (13.4%) in the standard-of-care arm received pathogen-directed treatment, corresponding to a reduction in absolute risk of 21.9 (95% CI, 13.5-30.3) percentage points and an odds ratio for the intervention arm of 3.53 (95% CI, 2.13-6.02; P < .001). The median (IQR) time to provision of pathogen-directed treatment within 48 hours was 34.5 (31.6-37.3) hours in the intervention arm and 43.8 (42.0-45.6) hours in the standard-of-care arm (mean difference, -9.4 hours; 95% CI, -12.7 to -6.0 hours; P < .001). The corresponding hazard ratio for intervention compared with standard of care was 3.08 (95% CI, 1.95-4.89). Findings remained significant after adjustment for season.

Lloyd M et al., 2019.[12]	Australia	Double-blind, stepped-wedge, cluster-randomized clinical trial.	917 patients.	A total of 917 patients were screened, and 816 (351 women and 465 men; mean [SD] age, 76 [13] years) were included in the intention-to-treat analysis, with 401 patients receiving the intervention and 415 patients in the control group. An unadjusted geometric mean ratio of 0.95 (95% CI, 0.78-1.16) was observed for the difference in length of stay (days) between the intervention and control groups. Similarly, no significant differences were observed for the secondary outcomes of mortality and readmission, and the results remained unchanged after further adjustment for sex and age. The study reported higher proportions of gastrointestinal bleeding in the intervention group (9 [2.2%]) compared with the controls (3 [0.7%]), with an unadjusted estimated difference in mean proportions of 0.008 (95% CI, 0.005-0.010).
Serigstad et al., 2023.[13]	Sweden	Randomized controlled trial.	439 ED patients with suspected CAP, we identified 103 patients with a retrospectively confirmed CAP and an available high-quality sputum sample with a paired OP sample.	For the most common CAP pathogens, Streptococcus pneumoniae and Haemophilus influenzae, the PPAs, NPAs, and overall agreement were 85%, 99%, and 95%, and 86%, 98%, and 93%, respectively. For Moraxella catarrhalis, the PPA was lower (74%), while the NPA was 100%. For bacteria less likely to cause uncomplicated CAP (e.g., Staphylococcus aureus and Enterobacterales), the results were more divergent.
Ibrahim D, et al., 2021.[14]	Lebanon	A retrospective	130 patients who underwent	Chest CT results were positive in 90.7% of patients, with 41.5% being newly diagnosed after negative or

		observational study.	CXR and chest CT within 48 hours were selected.	inconclusive CXR and 21.5% being diagnosed with add-on to the CXR findings. CT had large, moderate, and no benefit over CXR in diagnosing or excluding CAP in 45.3%, 21.5%, and 33.1% of patients, respectively.
Alexander et al., 2019. [15]	Multiple center.	A phase 3, noninferiority randomized clinical trial.	738 randomized patients.	Among 738 randomized patients (mean age, 57.5 years; 351 women [47.6%]; 360 had a PORT risk class of III or IV [48.8%]), 707 (95.8%) completed the trial. Early clinical response rates were 90.8% with lefamulin and 90.8% with moxifloxacin (difference, 0.1% [1-sided 97.5% CI, -4.4% to ∞]). Rates of investigator assessment of clinical response success were 87.5% with lefamulin and 89.1% with moxifloxacin in the modified ITT population (difference, -1.6% [1-sided 97.5% CI, -6.3% to ∞]) and 89.7% and 93.6%, respectively, in the clinically evaluable population (difference, -3.9% [1-sided 97.5% CI, -8.2% to ∞]) at test of cure. The most frequently reported treatment-emergent adverse events were gastrointestinal (diarrhea: 45/368 [12.2%] in lefamulin group and 4/368 [1.1%] in moxifloxacin group; nausea: 19/368 [5.2%] in lefamulin group and 7/368 [1.9%] in moxifloxacin group).
Bai et al., 2024. [16]	Canada	Retrospective cohort study.	23,512 patients.	Of 23,512 patients, 9,340 patients (39.7%) received BL+M, 9,146 (38.9%) received BL, 4,510 (19.2%) received FQ, and 516 (2.2%) received BL+D. The number of in-hospital deaths was 703 (7.5%) for the BL+M group, 888 (9.7%) for the BL group, 302 (6.7%) for the FQ group, and 31 (6.0%) for the BL+D group. The adjusted risk difference for in-hospital mortality when compared with BL+M was 1.5% (95% CI, -0.3% to 3.3%) for BL, -0.9% (95% CI, -2.9% to 1.1%) for FQ, and -1.9% (95% CI, -4.8% to 0.9%) for BL+D. Compared with BL+M, the subdistribution hazard ratio for being discharged alive was 0.90 (95% CI, 0.84-0.96) for BL, 1.07 (95% CI, 0.99-1.16) for FQ, and 1.04 (95% CI, 0.93-1.17) for BL+D.

Table 3. Critical appraisal of Study

Parameters	Mobergg et al. (2020) BJGP Open	Mobergg et al. (2020) Scand J Prim Health Care	Launders et al. (2019)	Markussen et al. (2024)	Lloyd et al. (2019)	Serigstad et al. (2023)	Ibrahim et al. (2021)	Alexander et al. (2019)	Bai et al. (2024)
1. Bias related to temporal precedence									
Is it clear in the study what is the "cause" and what is the "effect" (ie, there is no confusion about which variable comes first)?	Yes, as diagnostic test usage trends were observed over time.	Yes, intervention and control groups were clearly defined.	Yes, CAP management was assessed over a specific timeframe.	Yes, intervention and control groups were randomized.	Yes, the intervention was implemented in a stepped-wedge design.	Yes, clear distinction between intervention and control.	Yes, retrospective but clear sequence of imaging modalities.	Yes, trial protocol clearly defined the intervention timeline.	Yes, antibiotic regimen comparisons were conducted in a structured time frame.
2. Bias related to selection and allocation									
Was there a control group?	No control group, all data were from	Yes, control group was included for	No formal control group,	Yes, randomized controlled design.	Yes, cluster-randomized stepped	Yes, randomized controlled trial.	No, retrospective observational study without a	Yes, randomized controlled trial.	No, retrospective cohort study.

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	primary care records.	comparison.	only observational data.		d-wedge trial.		comparator.		
3. Bias related to confounding factors									
Were participants included in any comparisons similar?	No direct matching or adjustments for confounders.	Some baseline characteristics accounted for, but confounders not fully adjusted.	Differences in patient characteristics were not fully controlled.	Yes, randomization reduces confounding risk.	Yes, stepped-wedge design helped account for confounders.	Yes, randomization minimizes confounding bias.	No, observational design limits confounding control.	Yes, controlled clinical trial with rigorous methodology.	Some confounders adjusted, but residual confounding may exist.
4. Bias related to administration of intervention/exposure									
Were the participants included in any comparisons receiving similar treatment/care, other than the exposure or intervention of interest?	No intervention, only observation of diagno	Some differences in CXR use and antibiotic prescri	Variation in CAP management approaches amon	Yes, both groups received comparable standard care.	Yes, all patients were managed under the same	Yes, standardized testing approach was used.	No intervention, only imaging comparison.	Yes, treatment arms followed strict protocols.	Variability in antibiotic regimens could introdu

stic trends.	ptions between groups.	g physicians.	protocol.					ce bias.

5. Bias related to assessment, detection, and measurement of the outcome

Were there multiple measurements of the outcome, both pre and post the intervention/exposure?	No pre/post comparisons, only trends analyzed.	No standardized method to assess outcomes.	Some measurements were inconsistent across cases.	Yes, multiple measurements were taken before and after intervention.	Yes, standardized measurements of outcomes.	Yes, PCR-based testing followed standardized protocols.	No, retrospective review may have inconsistencies.	Yes, outcomes measured using predefined clinical criteria.	Yes, consistent outcome measurement across hospitals.
Were the outcomes of participants included in any comparisons measured in the same way?	Yes	Yes	Yes	Yes	Yes	Yes	No (Retrospective)	No (Retrospective)	No (Retrospective)
Were outcomes measured in a reliable way?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

6. Bias related to participant retention

Was follow-up complete and, if not, were differences between groups in terms of their follow-up adequately described and analyzed?	Not applicable (register-based study).	No mention of follow-up losses.	No follow-up since it was an obser	Yes, follow-up was complete.	Yes, follow-up was accounted for in the	Yes, participants were tracked through PCR	Not applicable (retrospective study).	Yes, patient retention was high (95.8%).	Not applicable (hospitalized cohort).

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		vational study.	analysis.	testing completion.					
7. Statistical conclusion validity									
Was appropriate statistical analysis used?	Yes, appropriate statistical tests used to analyze trends.	Statistical analysis conducted but some comparisons lacked power.	Some statistical tests performed, but limited adjustments for confounders.	Yes, rigorous statistical analysis applied.	Yes, appropriate methods for a stepped-wedge trial.	Yes, robust statistical validation.	Yes, CT vs. CXR comparisons were appropriately analyzed.	Yes, noninferiority margin and statistical methods clearly defined.	Yes, large dataset with appropriate statistical modeling.

DISCUSSION

The findings from the included studies provide valuable insights into the diagnostic, management, and treatment strategies for community-acquired pneumonia (CAP) across different healthcare settings. The study by Moberg et al. (2020) highlights a significant increase in the use of diagnostic tests, such as C-reactive protein (CRP) and chest X-rays (CXR), in primary care settings in Sweden over time. The use of CRP for pneumonia diagnosis rose from 61.3% to 77.5%, while its use for acute bronchitis increased from 53.4% to 65.7%. Similarly, the use of microbiological tests for pneumonia increased from 1.8% to 5.1%. These trends suggest a shift toward more evidence-based diagnostic practices, which may

contribute to improved accuracy in identifying CAP. However, the study also noted a decrease in antibiotic prescription rates for acute bronchitis, indicating a growing awareness of antibiotic stewardship. Despite these advancements, the lack of change in antibiotic prescribing for pneumonia underscores the need for further interventions to optimize antibiotic use in CAP management.[8]

In another study by Moberg et al. (2020), the use of CXR in primary care was evaluated through an intervention study. The results showed that 85% of patients in the intervention group were referred for CXR, compared to only 26% in the control group. However, the antibiotic prescribing rates did not differ significantly between the two groups, suggesting that while CXR use increased, it did not directly influence antibiotic prescribing decisions. Notably, 24% of patients with negative CXR results were still prescribed antibiotics, highlighting potential gaps in the interpretation of diagnostic results and the need for better integration of diagnostic findings into clinical decision-making.[9]

Launders et al. (2019) conducted a large prospective cohort study in the UK, analyzing 4734 episodes of CAP managed in primary care. The study revealed low utilization of CRB65 scores, a tool for assessing CAP severity, with only 0.4% of episodes recording this metric. This finding suggests underutilization of risk stratification tools in primary care, which could impact the appropriate management and referral of CAP patients. The most commonly prescribed antibiotic was amoxicillin, with 85.9% of episodes involving a seven-day course, aligning with guideline recommendations. However, the low recording of CRB65 scores indicates a need for greater adherence to clinical guidelines to ensure optimal patient outcomes.[10]

Markussen et al. (2024) demonstrated the benefits of syndromic molecular testing in CAP diagnosis through a randomized clinical trial. The intervention group, which received syndromic PCR-based testing, showed a significant increase in pathogen-directed treatment (35.3% vs. 13.4%) and a reduction in time-to-treatment initiation (34.5 hours vs. 43.8 hours) compared to the standard-of-care group. These findings underscore the potential of rapid molecular diagnostics to improve treatment precision and efficiency in CAP management. However, the study also highlights the importance of clinical evaluation to interpret positive

results, particularly for pathogens less commonly associated with uncomplicated CAP.[11]

The study by Lloyd et al. (2019) evaluated the effectiveness of a bundled intervention, including adjunctive corticosteroids, in hospitalized CAP patients. While the intervention did not significantly reduce length of stay, mortality, or readmission rates, it was associated with a higher incidence of gastrointestinal bleeding in the intervention group. This finding raises concerns about the safety of adjunctive corticosteroids in CAP management and emphasizes the need for careful patient selection and monitoring when using such therapies.[12]

Serigstad et al. (2023) explored the diagnostic utility of oropharyngeal (OP) swabs as an alternative to lower respiratory tract (LRT) samples for syndromic PCR testing in CAP patients. The study found high positive percent agreement (PPA) and negative percent agreement (NPA) for common CAP pathogens, such as *Streptococcus pneumoniae* and *Haemophilus influenzae*, when comparing OP and LRT samples. This suggests that OP swabs could serve as a viable alternative for rapid microbiological testing, particularly in settings where obtaining LRT samples is challenging. However, the lower PPA for *Moraxella catarrhalis* and divergent results for less common pathogens highlight the need for clinical correlation when interpreting test results.[13]

Ibrahim et al. (2021) compared the diagnostic accuracy of chest CT and CXR in CAP patients, finding that CT had a significant advantage over CXR in diagnosing CAP, particularly in cases where CXR results were inconclusive or negative. This study underscores the value of advanced imaging techniques in improving diagnostic accuracy, especially in complex or ambiguous cases. [14]

Finally, Alexander et al. (2019) conducted a randomized clinical trial comparing oral lefamulin to moxifloxacin for CAP treatment. The study found that lefamulin was noninferior to moxifloxacin in terms of early clinical response and investigator-assessed clinical success. However, lefamulin was associated with higher rates of gastrointestinal adverse events, such as diarrhea and nausea. These findings highlight the importance of balancing efficacy and tolerability when selecting antibiotics for CAP treatment.[15]

The study by Bai et al. (2024) provides critical insights into the comparative effectiveness of first-line and alternative antibiotic regimens for hospitalized patients with nonsevere community-acquired pneumonia (CAP). This large multicenter retrospective cohort study analyzed 23,512 patients and compared outcomes among those treated with beta-lactam plus macrolide (BL+M), beta-lactam alone (BL), fluoroquinolone (FQ), and beta-lactam plus doxycycline (BL+D). The results revealed notable differences in in-hospital mortality and discharge rates across the treatment groups.[16]

Pneumonia, an acute infection of the lung parenchyma caused by various microorganisms, remains a leading cause of morbidity and mortality worldwide. It is broadly categorized into **Community-Acquired Pneumonia (CAP)**, which occurs outside the hospital setting, and **Hospital-Acquired Pneumonia (HAP)**, which develops after at least 48 hours of hospitalization. A subset of HAP, **Ventilator-Associated Pneumonia (VAP)**, occurs in patients on mechanical ventilation and is excluded from this discussion due to its distinct pathophysiology and management.[17,18]

Pathophysiology

Pneumonia typically results from the aspiration of oropharyngeal secretions containing pathogens like *Streptococcus pneumoniae*, *Haemophilus influenzae*, and gram-negative bacilli. Microaspiration is common, even in healthy individuals, but progression to pneumonia depends on factors such as the volume and virulence of aspirated bacteria, frequency of aspiration, and the host's immune response. Comorbidities like chronic malnutrition, alcoholism, and diabetes can impair immune defenses, increasing susceptibility. Intracellular bacteria (e.g., *Mycoplasma pneumoniae*, *Chlamydia pneumoniae*, *Legionella* spp.) and viruses often enter the lungs via inhalation, with infection progression depending on the inoculum size and the ability of pathogens to evade host defense. [19]

Epidemiology

Pneumonia is a major global health burden, ranking as the eighth leading cause of death in the U.S. and the fourth worldwide. In low-income countries, it is the leading cause of death. The true incidence of CAP is likely underestimated, as mild cases often go undiagnosed. *S. pneumoniae* is the most common bacterial

pathogen in CAP, accounting for over 25% of cases globally. Disease severity influences the likelihood of specific pathogens; milder cases are often caused by *M. pneumoniae*, *C. pneumoniae*, and viruses, while severe cases may involve *S. aureus*, *Legionella*, and *H. influenzae*. HAP, on the other hand, is more likely to involve gram-negative bacilli like *Pseudomonas aeruginosa* and *Klebsiella pneumoniae*, with multidrug-resistant (MDR) pathogens such as MRSA and ESBL-producing bacteria being common in hospital settings. [17,18]

Clinical Presentation

Pneumonia typically presents with acute lower respiratory tract symptoms such as fever, cough, dyspnea, and increased sputum production. However, atypical presentations, especially in elderly patients, may include non-respiratory symptoms like confusion, malaise, and diarrhea, leading to delayed diagnosis and treatment. The distinction between "typical" and "atypical" presentations is no longer useful for predicting causative organisms, as there is significant overlap in pathogens. [19]

Diagnostics

Diagnosis relies on clinical evaluation and imaging. Chest X-rays are commonly used, though their sensitivity is limited (38%-75%). Computed tomography (CT) is more accurate but less accessible. Point-of-care ultrasonography is emerging as a valuable tool, offering real-time imaging without radiation. Laboratory tests, including complete blood counts and serum chemistry, help assess infection severity and organ involvement. Procalcitonin (PCT) can differentiate bacterial from viral infections, guiding antibiotic use. Microbiologic testing, such as sputum cultures, blood cultures, and urinary antigen tests for *S. pneumoniae* and *Legionella*, is recommended for hospitalized patients, particularly those with severe disease. Polymerase chain reaction (PCR) testing can detect multiple pathogens simultaneously but may not distinguish between infection and colonization.[19-20]

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Table 2. Causative Organisms and Suggested Diagnostics by Pneumonia Type and Severity[17]

Pneumonia Type and Severity	Common Causative Organisms	Suggested Diagnostics
CAP: Outpatient	*Mycoplasma pneumoniae*, *Streptococcus pneumoniae*, *Chlamydophila pneumoniae*, respiratory viruses	• None routinely
CAP: Non-ICU, Low Severity	*S. pneumoniae*, *M. pneumoniae*, *C. pneumoniae*, respiratory viruses	• Sputum bacterial culture • Respiratory viral PCR
CAP: Non-ICU, Moderate Severity	*S. pneumoniae*, *Staphylococcus aureus*, *Haemophilus influenzae*, *Legionella* species, respiratory viruses	• Sputum bacterial culture • Blood bacterial culture • Respiratory viral PCR • Pneumococcal urinary Ag • *Legionella* urinary Ag
CAP: ICU, High Severity	*S. pneumoniae*, enteric gram-negative bacilli, *S. aureus*, *H. influenzae*, *Legionella* species, respiratory viruses, *Pseudomonas aeruginosa*	• Sputum bacterial culture • Blood bacterial culture • Respiratory viral PCR • Pneumococcal urinary Ag • *Legionella* urinary Ag • Consider bronchoscopy
HAP (Non-VAP)	*S. pneumoniae*, enteric gram-negative bacilli, *S. aureus*, *P. aeruginosa*	• Sputum

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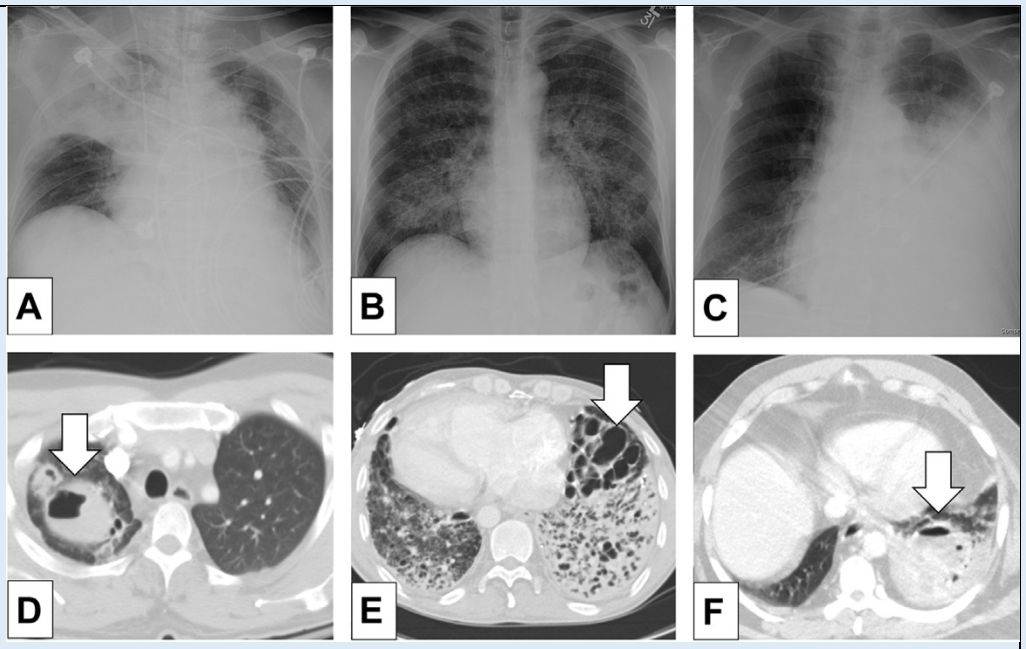


Fig. 1. Variations in radiographic appearance of pneumonia. (A) Lobar consolidation of the right upper lobe. (B) Bilateral interstitial infiltrates. (C) Large left parapneumonic pleural effusion. (D) Right upper lobe cavitary lesions (white arrow). (E) Diffuse bronchiectasis involving primarily the anterior left lower lobe (white arrow). (F) Pulmonary abscess with air fluid level in the posterior left lower lobe (white arrow).[2,3]

Management

Treatment depends on disease severity and setting. For **CAP**, outpatient management typically involves oral macrolides or doxycycline, while hospitalized patients may require intravenous β-lactams combined with macrolides or respiratory fluoroquinolones. ICU patients often need broader coverage, including antipseudomonal and MRSA agents. For **HAP**, empiric therapy targets gram-negative bacilli and *S. aureus*, with MRSA coverage if risk factors are present. Antibiotic duration is typically 5-7 days for CAP and 7 days or less for HAP, with de-escalation based on microbiologic findings. Adjunctive therapies like noninvasive ventilation (NIPPV) and high-flow nasal cannula (HFNC) can reduce intubation rates and mortality in severe cases. Corticosteroids may benefit severe CAP but should be avoided in viral, fungal, or mycobacterial infections. [2,4,16-20]

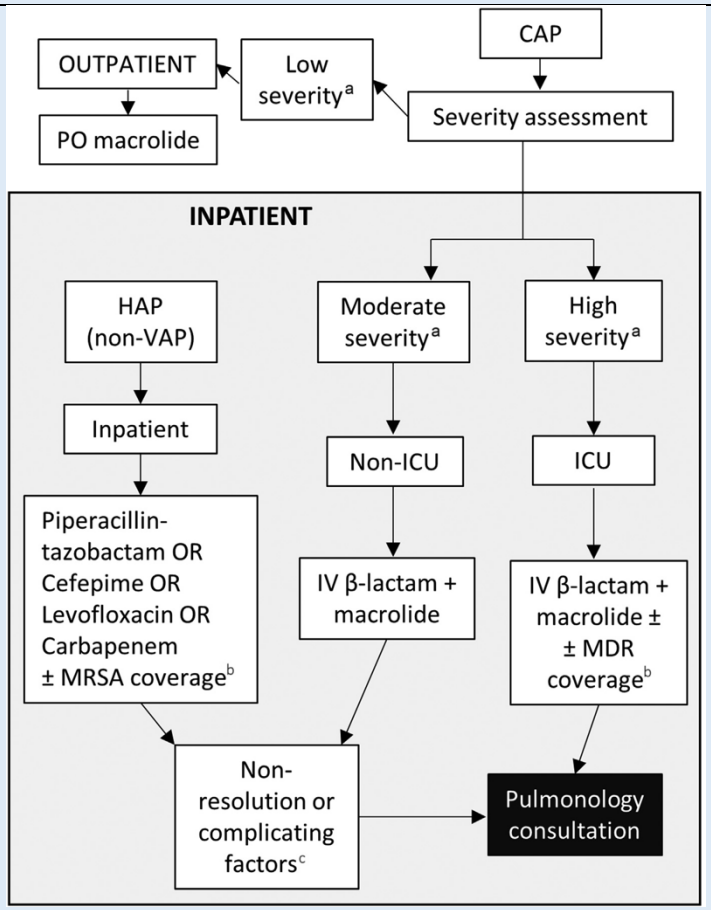


Fig. 3. Management algorithm for CAP and HAP. a Based on clinical judgment and severity score such as Pneumonia Severity Index or CURB-65 (confusion, urea nitrogen, respiratory rate, blood pressure, age 65 years). b Dependent on patient-specific and unit-specific risk factors for drug resistance. c See Box 1. IV, intravenous; PO, by mouth

Complications

Pneumonia can lead to complications such as parapneumonic effusions, empyema, lung abscesses, and cardiovascular events like myocardial infarction and arrhythmias. Prompt drainage is essential for complicated effusions, while lung abscesses may require surgical intervention in severe cases. [19-20]

Prevention

Preventive measures include addressing behavioral risk factors (e.g., smoking, alcoholism) and vaccination. Annual influenza vaccination is recommended for all individuals over 6 months, with priority for older adults and immunocompromised patients. Pneumococcal vaccines (PCV13 and PPSV23) are recommended for adults over 65 and those at high risk.[3]

Outcomes

CAP mortality rates are approximately 5% in outpatients, 15% in hospitalized patients, and 36% in ICU patients. Gram-negative organisms and *S. aureus* are associated with higher mortality. Thirty-day readmission rates range from 7% to 18%, often due to recurrent pneumonia or exacerbations of comorbidities.[20-22]

CONCLUSION

Pneumonia remains a complex and challenging condition due to its varied presentations, causative organisms, and severity. Advances in diagnostics, such as PCR and point-of-care ultrasonography, have improved detection, but antibiotic stewardship and tailored treatment remain critical to managing CAP and HAP effectively. In conclusion, the included studies demonstrate significant advancements in the diagnosis and management of CAP, including the increased use of diagnostic tests, the potential of syndromic molecular testing, and the exploration of alternative sampling methods. However, challenges remain, such as the underutilization of risk stratification tools, the need for better integration of diagnostic findings into clinical decision-making, and the importance of monitoring treatment safety. Future research should focus on optimizing diagnostic and treatment strategies to improve patient outcomes while minimizing risks and promoting antibiotic stewardship.

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