


Guideline Concordance in Managing Community-Acquired Pneumonia: Room for Improvement

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Objective: To assess contemporary concordance of inpatient management of community-acquired pneumonia (CAP) with guideline recommendations relating to use of severity assessment tools (SAT), antimicrobials and microbiological investigations.

Methods: A single-centre, retrospective audit involving patients admitted with CAP to medical inpatient units of a tertiary hospital between September 2019 and March 2020 using electronic medical record review. SAT scores were retrospectively calculated for all patients, and the appropriateness of interventions determined with reference to local guidelines.

Results: Of 200 patients of mean age 64 years, 58% were admitted to general medicine units and the remainder to other specialties. Treating clinicians recorded a SAT in 9% (18/200) of the patients, with calculated scores rating 58% of all cases as being mild. Antibiotic prescribing on admission was guideline-concordant in 16.0% of the patients, but significantly higher among patients with moderate-to-severe vs mild CAP (24% vs 10%; $p=0.01$). Step-down oral antibiotic prescribing was guideline-concordant in 39% of the patients, and significantly higher among younger (<65 years) vs older patients (51% vs 31%; $p=0.006$) and those with longer (>7 days) vs shorter length of stay (57% vs 34%; $p=0.007$). No significant differences in concordance were seen between different specialties. Among patients for whom blood cultures and sputum cultures were requested, only 2% (2/110) and 17% (15/86) respectively yielded a positive result.

Conclusion: This study suggests infrequent use of SATs, low guideline concordance for antibiotic prescribing, and the need for more selective use of blood cultures. Reasons underpinning inappropriate antibiotic prescribing and strategies for reversing it need to be identified.

Keywords: community-acquired pneumonia, guideline concordance, risk stratification, microbiological investigations, antibiotics

Introduction

Community-acquired pneumonia (CAP) is defined as a lower respiratory infection with onset in the community or within 48 hours of hospitalization.¹ Respiratory infections are a common cause for hospitalisations and mortality in Australia.^{2,3} The precise incidence of CAP is uncertain⁴ but is estimated at about 2 per 1000 people per year and accounts for about 2% of hospital admissions.⁵

Clinical guidelines from various jurisdictions help guide management of patients with CAP^{1,6,7} regarding the choice of initial antibiotics and use of severity assessment tools (SATs) that risk stratify patients in determining need for admission or likelihood of death or other adverse outcomes. The SMART-COP (systolic blood pressure, multi-lobar chest radiography involvement, albumin level, respiratory rate, tachycardia, confusion, oxygenation, and arterial pH) score, with a range 0 to 11, is one such tool that is commonly used and validated in Australian settings for identifying patients likely to require intensive respiratory or vasopressor support, as well as estimating 30-day mortality.⁸ Other SATs include the Pneumonia Severity Index (PSI) in the US⁷ and the CURB-65 (confusion, urea, respiratory rate, systolic or diastolic blood pressure, and age ≥ 65 years) in the UK.⁶

Adherence to clinical guidelines has been shown to decrease patient mortality, reduce duration of hospital stay,⁹ and improve cost-effectiveness of patient care.¹⁰ Despite these benefits, concordance with guideline recommendations in the care of CAP patients is often poor,¹¹ and varies in Australian hospitals between 5% and 59%¹² based on studies performed more than 7 years ago.

This study aimed to provide a contemporary review of the management of CAP in a tertiary hospital and determine concordance with local guidelines regarding 1) use of SMART-COP; 2) use of antibiotics; and 3) use and yield of microbiological investigations.

Materials and Methods

A single centre, retrospective cohort study was undertaken of consecutive patients admitted to inpatient wards of Princess Alexandra Hospital over the period between September 1, 2019 and March 31, 2020, and who had a discharge diagnosis of pneumonia coded as International Classification of Diseases version 10 (ICD-10) code J09-J19. These records were identified through the hospital's health information management system and corresponding electronic medical records were retrieved. Selection criteria were derived from the International Community-acquired Pneumonia Organisation (CAPO) study protocol.¹³ Inclusion criteria comprised 1) radiological evidence (chest X-ray or computed tomography [CT] imaging) 48 hours before or after admission demonstrating new pulmonary infiltrate; and 2) one of the following clinical signs and symptoms: fever $\geq 38^{\circ}\text{C}$ or hypothermia $\leq 35.5^{\circ}\text{C}$, changes in white cell count (leucocytosis or leukopenia) or new or increased cough and/or new or increased sputum. Exclusion criteria comprised 1) provisional diagnosis of hospital acquired pneumonia (defined as new onset pneumonia that occurred more than 48 hours after being hospitalised and not incubating at time of admission); 2) discharge diagnosis not consistent with CAP; 3) alternative diagnosis that adequately explained the clinical findings; and 4) palliative patients with pre-existing expressed wishes for no active intervention.

Data Collection

Data were collected on the following variables:

Patient characteristics: age, gender, place of residence; length of hospital stay (LOS); pre-existing co-morbidities (pulmonary conditions, obstructive sleep apnoea [OSA], heart failure, diabetes, chronic kidney disease, renal replacement therapy, rheumatoid arthritis, immunodeficiency state, chronic liver disease, or motor neuron disease); pneumococcal vaccination status if known; smoking status; alcohol misuse; need for domiciliary oxygen; SAT documented by treating team with severity scores; data required to calculate the SMART-COP score for each patient; cardiac complications including acute myocardial infarction and/or presence of cardiac arrhythmia; in-patient death; and readmissions to Queensland public hospitals with CAP within 30 days of discharge, ascertained by reviewing the state-wide Viewer software program.

Clinical care: intensive care unit admission (ICU) and ICU LOS; use of invasive or non-invasive ventilation (NIV); microbiological investigations for CAP including blood cultures, sputum cultures, urinary antigen tests, atypical organism serology, yield of pathogenic organisms and changes in antibiotic therapy according to pathogen and sensitivities; antibiotic use prior to admission; penicillin allergy status and drug reactions during hospitalisation; initial (empirical) antibiotics use; duration of intravenous (IV) antibiotic therapy; subsequent oral antibiotics prescribed, which took account of microbiological results; and time to conversion to oral therapy following onset of clinical stability, defined as resolution of fever/hypothermia for at least 48 hours, improvement in clinical signs and symptoms (including hypotension, tachycardia, oxygen saturation, respiratory rate, symptomatic improvement) and ability to tolerate oral intake.

Vaccination information was derived from available Medicare-recorded immunisation records via My Health Record. Scores for SMART-COP were calculated retrospectively for every patient by one investigator (AT) using extracted data. Variables used to calculate the scores were considered to have normal values if relevant data were not available. De-identified data were collated into an Excel spreadsheet and the SMART-COP score (with range 0 to 11) was calculated automatically. Depending on the severity scores, the cases were classified mild (score 0–2), moderate (score 3–4) or severe (score 5 to 11).

Reference Standard

The Metro-South Health (MSH) antibiotic guidelines¹⁴ issued in 2020 were used as the reference for determining guideline concordance for antibiotic prescribing, and which recommend a beta-lactam as the mainstay antibiotic for mild or moderate severity CAP, with a macrolide or doxycycline added to cover for atypical organisms, including gentamicin in severe cases to provide gram-negative cover ([Appendix 1](#)). Amoxicillin, with or without doxycycline or roxithromycin, was recommended as step-down oral therapy. Variations in recommended antibiotics and duration of therapy were considered acceptable (ie, guideline-concordant) on a case-by-case basis according to documented penicillin allergy/drug reactions, recommendations of attending Infectious Disease specialists and patient-specific clinical factors: febrile neutropenia, receiving immunosuppressive therapy, currently enrolled in clinical trials, clinical concerns about route of administration (eg, dysphagia) or comorbid conditions influencing antibiotic use (eg, renal insufficiency).

Outcome Measures

Whole cohort analyses were undertaken in defining patient characteristics, use of, and calculated scores for, SMART-COP, guideline concordance in choice, dose, duration, and route of administration of initial and subsequent antibiotics, and choice and yield of microbiological investigations. Additional subgroup analyses were performed comparing A) SMART-COP scores for 1) patients admitted to ICU/receiving NIV/dying in hospital versus scores for remaining patients and 2) patients undergoing microbiological investigations versus none; and B) guideline-concordant antibiotic prescribing in patients: 1) ≥ 65 years versus < 65 years of age; 2) admitted to general medicine units versus other specialty units; 3) with SMART-COP scores for mild disease vs moderate-to-severe disease; 4) with pre-existing pulmonary disease vs no disease; 5) with diabetes or immunodeficiency vs none; 6) with LOS ≤ 7 days vs > 7 days; and 7) readmitted at 30 days vs no readmission.

Statistical Analyses

Analyses were completed in Excel and descriptive statistics were used to present means (standard deviations [SD]), medians (interquartile range [IQR]) and proportions. Comparisons of proportions and means used chi-square tests (or Fisher's exact tests for small samples) and Student's *t*-test respectively. De-identified data were stored in a password-protected Microsoft Excel file only accessible to the investigators. Ethics approval was granted by the Metro South Human Research Ethics Committee (LNR/2020/QMS/60898). A waiver of consent was granted, given that the retrospective collection of data carries no foreseeable risk of harm to the participants.

Results

A total of 349 patient records were retrieved from the hospital database of which 200 admissions met selection criteria and were included for analysis.

Patient Characteristics

Mean age was 64 (\pm SD 18.9) years, 61% were male, and 15% were living in a residential age care facility at the time of admission ([Table 1](#)). The admitting unit was general medicine for 56.5% of the patients.

Pre-existing pulmonary conditions were documented in 70 (35%) patients, although none were receiving domiciliary oxygen. A minority of patients (32 [16%]) were current smokers, 35 (17%) had diabetes and 29 (14.5%) were receiving immunosuppressive medications or had diagnosed immunodeficiency. Only 3 patients had a recorded pneumococcal vaccine status, and 26 patients had a documented penicillin allergy.

Clinical Course

Median length of stay was 4 days (IQR 5) and 8 (4%) patients died in hospital. The mean age of patients that died in hospital was 82 (\pm SD 6.7) years. Admission to ICU occurred in 8 (4%) patients with median ICU stay of 2 (IQR 0.8) days, and 3 (1.5%) patients received NIV during admission. Complications comprised myocardial infarction in 4 (2%) patients and arrhythmias in 12 (6%), and 16 (8%) were readmitted at 30 days with CAP.

Table 1 Patient Characteristics (n=200)

Mean Age (\pm SD) Years	64 (\pm 18.9)
Male	61% (122)
Living in residential age care facility	15% (30)
Pre-existing pulmonary conditions	35% (70)
<i>Chronic obstructive pulmonary disease</i>	20% (40)
<i>Asthma</i>	6% (12)
<i>Bronchiectasis</i>	1.5% (3)
<i>Interstitial lung disease</i>	2% (4)
<i>Asbestos-related lung disease</i>	1.5% (3)
<i>Lung cancer</i>	2% (4)
<i>Others</i>	2% (4)
Obstructive sleep apnoea	16% (32)
Heart failure	13% (25)
Diabetes	17% (35)
Chronic kidney disease (CKD) stage	26% (52)
CKD 1–4	19% (37)
CKD 5 (on dialysis)	6% (12)
CKD 5 (not on dialysis)	1.5% (3)
Receiving immunosuppressive medications or known immunodeficiency	14.5% (29)
Current smoker	16% (32)
History of alcohol misuse	6% (11)
Number of co-morbid conditions	
0	31% (62)
1	28% (56)
2	18% (36)
3	16% (32)
4	5% (10)
5	2% (4)
Pneumococcal vaccine	1.5% (3)
Length of stay (median [IQR] days)	4 days [IQR 5]
Severity of CAP based on calculated SMART-COP scores	
Mild	58% (116)
Moderate	19% (39)
Severe	23% (45)
Requiring non-invasive ventilation	1.5% (3)
Admission to Intensive Care Unit	4% (8)
Duration of admission (median [IQR] days)	2 days [IQR 0.8]
In-hospital mortality	4% (8)
Complications	
<i>Acute myocardial infarction</i>	2% (4)
<i>Arrhythmias</i>	6% (12)
Readmissions at 30 days	8% (16)

(Continued)

Table 1 (Continued).

Admitting unit	
General Medical Units	56.5% (113)
Respiratory	12.5% (25)
Oncology/haematology	7.5% (15)
Renal	6% (12)
Emergency Department (short stay)	5.5% (11)
Cardiology	3% (6)
Intensive Care Unit	3% (6)
Transplant Unit	2.5% (5)
Other Units	3.5% (7)

Abbreviations: SD, standard deviation; IQR, interquartile range; CAP, community-acquired pneumonia.

Severity Assessment

Use of a SAT was documented for 18 (9%) patients, SMART-COP in 15 and CURB-65 in 3. Most patients (96%) had data available on the variables used to retrospectively calculate a SMART-COP score; in the remaining 8 (4%) patients, pH was not available in the absence of blood gas analyses at presentation. Among those with a SMART-COP score documented by the admitting unit, 3 underestimated severity compared with the calculated score, 9 were concordant and 1 overestimated severity. The calculated SMART-COP score for all patients categorised the cohort as having mild disease in 116 (58.0%), moderate disease in 39 (19.5%) and severe disease in 45 (22.5%).

Microbiological Investigations

The most frequent investigation and corresponding yield was a blood culture (n=109, 54.5%; yield 2%), followed by *Pneumococcus* and *Legionella* urine antigen tests (n=88, 44%; 7%), sputum culture (n=86, 43%; 17%) and atypical pneumonia serology (n=73; 34%; 14%) (Table 2). Equal numbers of tests per patient (1.8) were performed in those with mild versus moderate-to-severe disease, and there were no differences between groups in frequency or yield of each type of investigation. A positive yield was seen in 33 of 356 investigations (9.3%). The frequency and corresponding proportion of a positive test that led to a change in therapy were blood cultures (n=2; 100%), sputum cultures (n=15; 53%), urine antigens (n=6; 50%) and atypical pneumonia serology (n=10; 20%). The most common causative organisms identified were *Haemophilus influenzae* and *Streptococcus pneumoniae* (5 cases each). Among 24 patients receiving antibiotics prior to admission, 11 had blood cultures (all negative) and 16 had sputum cultures of which two were positive.

Antibiotic Prescribing

Initial antibiotic prescribing was guideline concordant in 32 of 200 patients (16.0%) (Table 3). On admission, the most frequently prescribed initial antibiotic regimens were IV benzylpenicillin and oral doxycycline (n=51, 26%), piperacillin–

Table 2 Yield of Microbiological Investigations According to CAP Severity

Microbiological Investigations	Proportion of Each Microbiological Investigation That Yielded a Positive Result		
	Mild CAP	Moderate-to-Severe CAP	Total
Blood culture	1/60 (1.6%)	1/49 (2.0%)	2/109 (1.8%)
Sputum culture	9/49 (18.4%)	6/37 (16.2%)	15/86 (17.4%)
<i>Pneumococcus</i> and <i>Legionella</i> urine antigen test	2/53 (3.8%)	4/35 (11.4%)	6/88 (6.8%)
Atypical pneumonia serology	7/45 (15.5%)	3/28 (10.7%)	10/73 (13.7%)
All investigations	19/207 (9.2%)	14/149 (9.4%)	33/356 (9.3%)

Table 3 Proportion of Guideline-Concordant Prescribing in Each Antibiotic Class

Antibiotic Class	Proportion of Guideline-Concordant Antibiotic Prescribing
Initial antibiotics	
Oral amoxicillin	6/6 (100.0%)
Oral doxycycline	1/1 (100%)
Oral moxifloxacin	2/3 (66%)
IV benzylpenicillin	17/82 (21%)
IV extended spectrum beta-lactams	1/40 (2.5%)
IV third-generation cephalosporin	4/50 (8.0%)
IV gentamicin	1/9 (11.1%)
Other antibiotics	0/9 (0%)
All antibiotics	32/200 (16.0%)
Stepdown oral antibiotics	
Amoxicillin and/or macrolide/doxycycline	37/43 (86.0%)
Amoxicillin–clavulanate	5/105 (5%)
Cefuroxime	7/10 (79%)
Quinolone	8/10 (80%)
Bactrim	2/2 (100%)
Azithromycin	1/2 (50%)
Doxycycline	5/6 (83%)
Flucloxacillin	1/1 (100%)
No antibiotics prescribed	12/15 (80%)
Other antibiotics	0/6 (0%)
All antibiotics	78/200 (39%)

tazobactam (n=30, 15%) and ceftriaxone and azithromycin in (n=30, 15%). Among 30 patients receiving ceftriaxone, only 16 (53%) had a documented penicillin allergy to account for its use. Guideline concordance within each antibiotic group ranged from as low as 2.5% for piperacillin–tazobactam to 100% for amoxicillin. Acceptable deviations from guidelines comprised penicillin allergy (n=6/32; 19%), concerns about dysphagia (n=2/32; 6%) and chronic kidney disease (n=1/32; 3%). Among the 168 patients with guideline-discordant initial antibiotic prescribing, 163 (97%) had incorrect antibiotics prescribed and 5 patients (3%) had incorrect dose charted. The mean duration of IV antibiotics was 3.5 (\pm SD 2.5) days. Most of the patients (n=144; 72%) patients were switched appropriately to oral therapy following determination of clinical stability. For the remaining 56 (28%) patients with delayed switch to oral antibiotics, reasons for this could not be ascertained from medical records.

Step-down antibiotic prescribing was guideline concordant in 78 of 200 patients (39.0%) (Table 3). The most frequently prescribed oral antibiotics comprised amoxicillin–clavulanate (86; 43%), amoxicillin and doxycycline combination (34; 17%) and amoxicillin–clavulanate with doxycycline (22; 11%). Guideline concordance ranged from as low as 5% for amoxicillin–clavulanate to 86% for amoxicillin with macrolide or doxycycline. Acceptable deviations comprised ID specialist recommendations (n=13/78, 16%), penicillin allergy (n=11/78, 14%), immunosuppression (n=1/78, 1%) and clinical trial enrolment (n=1/78, 1%). Among the 122 patients with guideline-discordant step-down oral antibiotic prescribing, 115 (94%) had incorrect antibiotics prescribed, 5 (4%) had incorrect dose and 2 (2%) had incorrect duration of therapy (too short or long duration).

Subgroup Analyses

Patients admitted to ICU, receiving NIV or dying in hospital had significantly higher SMART-COP scores compared to other patients (mean [SD] 5.8 [2.8] vs 2.3 [1.9]; $p < 0.001$). In contrast, scores for patients undergoing microbiological investigations were similar to those of non-investigated patients (mean [SD] 2.5 [2.2] vs 2.6 [2.3]; $p = 0.74$). Among

Table 4 Subgroup Analyses of Guideline-Concordant Antibiotic Prescribing

Subgroups	Initial Antibiotics			Stepdown Oral Antibiotics		
	Proportion of Patients with Guideline-Concordant Prescribing		p-value	Proportion of Patients with Guideline-Concordant Prescribing		p-value
Age	≥65 years	<65 years		≥65 years	<65 years	
	20/121	12/79	0.80	38/121	40/79	0.006*
Admitting Units	General medicines	Sub-speciality		General medicine	Sub-speciality	
	23/116	9/84	0.08	42/116	36/84	0.34
SMART-COP score indicating severity	Mild	Moderate-to-severe		Mild	Moderate-to-severe	
	12/116	20/84	0.01*	51/116	27/84	0.09
Presence of pre-existing pulmonary disease	Yes	No		Yes	No	
	9/71	23/129	0.34	24/71	54/129	0.26
Presence of pre-existing diabetes/immunodeficiency	Yes	No		Yes	No	
	10/59	22/141	0.81	20/59	58/141	0.34
Length of stay	≤7 days	>7 days		≤7 days	>7 days	
	26/160	6/40	0.73	55/160	23/40	0.007*
If patient was readmitted at 30 days	Yes	No		Yes	No	
	3/16	29/184	0.72 [#]	7/16	71/184	0.69

Notes: *Indicating p-value<0.05. [#]Analysis completed using Fisher's exact tests.

patient subgroups (Table 4), initial antibiotic prescribing was more guideline-concordant in those with moderate-to-severe CAP than in mild CAP (20/84, 24% vs 12/116, 10%; p=0.01). Step-down oral antibiotic prescribing was more guideline-concordant in younger than in older patients (40/79, 51% vs 38/121, 31%; p=0.006) and in those with longer than shorter LOS (23/40, 57% vs 55/160, 34%; p<0.001). No significant differences were seen between general medicine and other specialty units in guideline-concordant use of antibiotics.

Discussion

The management of CAP is challenging for various reasons. In older, multi-morbid patients, accurate assessment of disease severity may be difficult because of the absence of classical features of high fever or clear-cut radiological signs used to calculate SATs. There is also an array of potential pathogens, more so in older or immunocompromised patients, that can be treated with different antibiotics associated with variable antimicrobial resistance patterns, as indicated by local antibiograms.

Documented use of a SAT to risk stratify patients in this study was low, with the SMART-COP score used in less than 1 in 10 patients. This is similar to observations in other Australian studies.^{12,15} Explanations may include clinician perceptions of low utility or being unaware of the tools or doubting their predictive accuracy. Notably, the American Thoracic Society/Infectious Diseases Society of America (ATS/IDSA) 2019 guidelines⁷ and the NICE 2014 guidelines¹⁶ recommend their use in conjunction with clinical judgement, and the current Australian Therapeutic Guidelines¹ primarily recommend a “red flags” system, while mentioning SMART-COP can also be used.

The SMART-COP score was originally intended to predict the need for respiratory or vasopressor support in admitted patients, with high sensitivity (92%) and negative predictive value (99%).⁸ However, among older, multi-morbid populations, its predictive accuracy is lower when compared to CURB-65,¹⁷ and many of these patients who may not benefit from ICU admission can usually be identified by clinical judgement. The SMART-COP is potentially more useful in younger patients in whom it performs better than the PSI and CURB-65 which tend to underestimate severity.¹⁸ While accepting the importance of clinical judgement,¹⁹ cognitive bias or other extraneous factors can predispose a clinician to misclassify the disease severity during initial triage.²⁰ In this study, patients with a worse prognosis did demonstrate higher SMART-COP scores and initial antibiotic prescribing was more guideline-concordant among those with moderate-to-severe disease. More consistent use of a SAT in categorising CAP severity may promote higher guideline concordant initial IV antibiotic prescribing, as recommended in several guidelines.^{1,6,14}

In regard to the choice of initial and subsequent antibiotics, our study revealed low concordance with local guidelines: 16% and 39%, respectively, considerably lower than the average 75% of all antibiotic prescribing in patients with CAP observed in a recent Australia-wide hospital survey.²¹ This significant disparity may relate to more in-depth analysis of medical records, use of more prescriptive local guidelines as the reference standard, and tertiary setting attracting a more at-risk population. However, similar results have been reported elsewhere,^{12,15} although use of ceftriaxone was much less in our study compared to other reports.^{15,22} Preferential use of extended spectrum penicillin in the absence of supporting clinical indications, such as febrile neutropenia, is of concern. The overuse of IV antibiotics in mild cases of CAP may relate to clinician misconception of oral antibiotics being less effective, despite evidence of similar efficacy in patients who tolerate oral administration.¹

Amoxicillin–clavulanate was frequently used as a step-down oral antibiotic despite its tendency to select out resistant organisms and having more adverse effects than amoxicillin.¹ In addition, as strains of *S. pneumonia* highly resistant to penicillin are seen in less than 2% of the cases,²¹ its indiscriminate use is unnecessary. The frequent use of amoxicillin–clavulanate as a step-down oral antibiotic might be attributed to clinicians wanting to cover aspiration pneumonia or a perceived increased patient adherence given the reduced frequency (twice daily versus three times daily) compared with amoxicillin. While the choice of antibiotics will depend on local resistance patterns, a penicillin and doxycycline or macrolide are regarded as the most appropriate therapy.^{1,23} Our observation that older patients received less guideline-concordant oral antibiotics may reflect a clinician perception that “stronger” broad spectrum antibiotics are needed in such patients, as reported in other studies.^{24,25} The same may apply to patients with shorter LOS in whom clinicians may “play safe” in light of reduced time available to confirm continued clinical stability.

In terms of microbiological investigations, less than 1 in 11 returned a positive result, and only 4 in 100 led to a change in antibiotic therapy. Guideline recommendations for such tests vary considerably (Table 5), with consensus being to reserve blood cultures for patients with fever or other features suggesting moderate-to-severe CAP and to

Table 5 Guideline Recommendations for Microbiological Investigations

	eTG ¹	ATS/IDSA ⁷	NICE ¹⁶
Sputum cultures	No specific recommendations but recommend pre-treatment sputum cultures if possible to obtain sample.	Only in severe CAP or if suspecting methicillin-resistant <i>Staphylococcus aureus</i> (MRSA)/ <i>Pseudomonas aeruginosa</i> (PA) infection Yield is low.	In moderate-to-severe CAP
Pneumococcal/ Legionella urine antigen testing	Only in severe CAP. Yield for pneumococcal urine antigen is low	Only in severe CAP	In moderate-to-severe CAP. Legionella antigen testing only if outbreaks
Blood cultures	Recommended in inpatients	Only in severe CAP or if suspecting MRSA/PA infection	In moderate-to-severe CAP
Atypical pneumonia serology	Not recommended as it will not affect acute management	Nil specific recommendations	No specific recommendations

Abbreviations: eTG, electronic Therapeutic Guidelines; ATS/IDSA, American Thoracic Society/Infectious Diseases Society of America; NICE, National Institute of Clinical Excellence; CAP, community-acquired pneumonia.

reserve sputum cultures for those productive of purulent phlegm. Serological tests for atypical organisms are not warranted due to long turnaround times and little impact on acute management.

In this study, both blood and sputum cultures had low yields, consistent with other published data.^{26–28} Urinary antigen or serological tests were also overused, with half of the tests being ordered in patients with only mild disease. Considering their cost, collection burden for staff, frequently misleading results (eg, false positives from contaminants) and low impact on management, ordering of microbiological investigations should be reserved for more severe CAP or in patients with risk factors.

Study Strengths and Limitations

This study provides a comprehensive analysis of contemporary risk assessment and use of antibiotics and microbial investigations in a large sample of patients with CAP admitted to medical units of a tertiary hospital. Various sub-group analyses have shed additional insights into the differential use of these interventions. It is limited by employing a single centre, retrospective study design reliant on detailed documentation in the medical records and the use of ICD-10 codes to identify suitable patients which may have not captured all cases of CAP. Certain variables (like respiratory rate and presence of confusion) used in the determination of SATs are also highly variable and rely on detailed documentation. Patients who died in the community after discharge from hospital or represented with CAP to private hospitals could not be ascertained. The MSH local antibiotic guidelines, rather than national guidelines, were used as the reference standard for antibiotic concordances as they are heavily promoted to staff, easily accessible electronically, and incorporate local microbiological resistance patterns and epidemiology. However, they do not include recommendations about investigations, and concordance rates for antibiotics might be different if national guidelines had been used.

Implications for Clinical Practice

Standardised, easy-to-implement CAP clinical pathways are needed. They should be based on the current available evidence in the appropriateness of risk assessment, antibiotic use and investigations, but also allow clinicians flexibility according to circumstances, provided justifiable reasons for discordance are documented. Ideally, this pathway should be integrated as a decision support tool into electronic medical records and easily accessible at the point of care to maximise adherence.^{29,30} Regular audits and peer-referenced feedback on antibiotic use, education campaigns and prompts around the costs of ordering investigations can all promote greater use of pathways^{31,32} in optimising care and patient safety.

Disclosure

The authors report no conflicts of interest in this work.

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