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Comparative Evaluation of Severity Scoring Systems for Predicting Clinical Outcomes in Community-Acquired Pneumonia

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ABSTRACT

Background: Community-acquired pneumonia (CAP) continues to be a leading cause of morbidity and mortality globally, particularly among hospitalized patients. The timely recognition of high-risk individuals is essential to facilitate management decisions. A number of severity scoring systems have been created to assist with predictions of clinical outcomes. However, the greater relative predictive accuracy of each severity score is still the subject of current research.

Objective: To formally compare scoring systems of CAP for predictive measures of mortality, intensive care unit (ICU) admission, need for mechanical ventilation, and need for vasopressors.

Methodology: This observational study was performed at Aziz Fatimah Hospital, Faisalabad with 92 adult patients with community-acquired pneumonia. Patients were evaluated for age, sex, clinical signs and symptoms, lab values, and radiological data. Scoring systems for the CAP severity (PSI, CURB-65, CORB, CRSI-65, SCAP, SMART-COP) were calculated for every patient.

Results: In total, 92 patients were included in the study. Greater severity scores were significantly associated with in hospital mortality, intensive care unit (ICU) admission, mechanical ventilation, and vasopressor use. SCAP and SMART-COP had the highest sensitivity and specificity for most outcomes. All six scoring systems had statistically significant predictive value ($p < 0.05$) across some or all of the outcomes.

Conclusion: SCAP and SMART-COP were consistently reliable scoring systems for predicting adverse outcomes for patients with CAP. The PSI had good sensitivity for mortality, but was less useful for rapid triage. CURB-65 and CORB had moderate predictive value. The use of an appropriate scoring system can assist timely assessment of risk and clinical decision-making.

Keywords: Intensive Care Unit; Community-Acquired Pneumonia; Six Severity Scoring Systems

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Introduction

Community-acquired pneumonia (CAP) is still one of the most prevalent infectious diseases in the world, and is associated with notable morbidity and mortality, especially in the elderly and elsewhere in people with co-morbidities. CAP accounts for millions of hospitalizations every year globally and is still an leading infectious disease cause of death by both developed and developing countries.[1] The early recognition of disease severity is paramount to guiding management decisions regarding the need for hospital admission, intensive care unit (ICU) admission, the use of advance supportive interventions such as mechanical ventilation, or the need for vasopressor therapy.[2]

Community-acquired pneumonia (CAP) presents a substantial clinical spectrum that can range from mild symptoms that can be managed in an outpatient setting to sepsis and respiratory failure, among other critical conditions. Therefore, risk stratification is important to ensure proper resource allocation, treatment initiation, and patient outcomes. Clinical prediction rules have been established to assist clinicians in assessing CAP severity and estimating important clinical outcomes such as morbidity and mortality.[3]

The Pneumonia Severity Index (PSI) is one such prognostic model that evaluates 20 variables including age, comorbidities, vital signs, and laboratory data. The PSI places patients into five risk categories where the risk of mortality is highest in classes IV and V.[4] While PSI is inclusive, it has also received criticism for being complicated and lengthy in time-sensitive settings.

The CURB-65 score is a more rapid screening tool derived from five simple clinical parameters (confusion, blood urea nitrogen, respiratory rate, blood pressure, and age ≥65) and is recommended for use in primary and emergency care by many clinical guidelines,[5] but it may lack sensitivity to pick out patients who will require ICU admission or mechanical ventilation.

To address some of these shortcomings, other tools have been proposed recently like the CORB score (confusion, oxygen saturation, respiratory rate, and blood pressure) and CRSI-65 (confusion, respiratory rate, shock index, and age ≥65) tools.[6,7] PGEM is reliant on simple, accessible bedside parameters, and will be useful in low-resource settings.

The SCAP (Severe Community-Acquired Pneumonia) score was created to optimize prediction of ICU needs and mortality. It includes several variables, such as arterial pH, systolic blood pressure, mental status, respiratory rate, and radiology [8]. The SMART-COP score (3 variables: systolic BP, multilobar infiltrates, albumin; 5 variables: respiratory rate, tachycardia, confusion, oxygenation, pH) has demonstrated some ability to identify patients in need of intensive respiratory or vasopressor support (IRVS).[9]

While we have these tools at our disposal, there remains clinical uncertainty about how to apply these scores with regard to their performance for a range of outcomes. Some might perform well for mortality prediction, but less well for ICU admission or for prediction of use of mechanical ventilation. Others may have better sensitivity, but less specificity which may lead to overuse of intensive care resources.[10,11]

Many studies have developed and validated these scores and have also compared the countries these scores were tested in. However, given both regional variation in what "patient" means (e.g. the population we treat, the innate abilities of the health systems in that region, patterns of disease), we need to acquire "local data" in order to adequately guide clinical practice. Furthermore, the majority of existing studies examine one or two outcomes of interest, with very few studies examining the relative utility of scores across a number of clinical endpoints-including mortality, need for ICU admission, need for mechanical ventilation, need for vasopressors.[12]

With the emphasis that risk stratification early in the disease course is critical in patients with community-acquired pneumonia and the presence of several severity scoring systems, we felt it was important to compare the predictive performance of different scoring systems across several clinically important outcomes. The purpose of this study was to examine and compare the predictive capability of six commonly used severity scores (PSI, CURB-65, CORB, CRSI-65 SCAP, and SMART-COP augmented with NEWS) to predict in-hospital mortality, ICU admission, need for mechanical ventilation, and vasopressor requirement in patients with CAP admitted at a tertiary care facility. This study aims to assist evidence-based decisions and optimize resources in managing patients with CAP by providing insights on the strengths and limitations of different severity scoring systems in our local adult population.

Objective

To formally compare scoring systems of CAP for predictive measures of mortality, intensive care unit (ICU) admission, need for mechanical ventilation, and need for vasopressors.

Methodology

This study was conducted as a prospective observational study for 12 months, from August 2023 to July 2024, at the Department of Pulmonology, Aziz Fatimah Hospital, Faisalabad. The main aim was to evaluate and compare the predictive performances of six severity scoring systems that are largely used in patients with community-acquired pneumonia (CAP) for mortality indexes, ICU admission, mechanical ventilation, and vasopressors.

A total of 92 adult patients were included consecutively

from the emergency department, medical wards, and ICU during the study duration. All included patients were aged ≥ 18 years and presented with a clinical and radiological diagnosis of CAP, which was defined as new infiltrates on chest imaging (X-ray or CT) and one or more of the following symptoms: fever (≥ 38 °C), cough, sputum, dyspnea, or pleuritic chest pain with symptom onset outside the hospital or within 48 hours of admission.

Patients were excluded if they had been hospitalized in the previous 14 days, had a confirmed diagnosis of hospital-acquired pneumonia or ventilator-associated pneumonia, active pulmonary tuberculosis, known bronchiectasis or malignancy of the lung, or were immunocompromised (HIV-infected individuals, chemotherapy within the past 30 days, chronic hemodialysis). Patients confirmed positive for COVID-19 by RT-PCR were also excluded.

After written informed consent was obtained from the participant or their legally authorized representative, structured demographic, clinical and laboratory data were collected using a structured proforma. The variables collected were age, sex, smoking status, comorbidity (diabetes mellitus, hypertension, cardiovascular disease, renal dysfunction, and neurological disorders), clinical parameters (temperature, pulse, respiratory rate, systolic and diastolic blood pressure, oxygen saturation, and mental status), and laboratory values (arterial blood gases, full blood count, serum urea, creatinine, electrolytes, liver function tests, and serum albumin). Radiographs were also reviewed to document multilobar involvement.

All participants received assessment with six validated severity scoring systems within the first 24 hours of presenting to the hospital. These measures were the Pneumonia Severity Index (PSI), CURB-65 (confusion, urea, respiratory rate, blood pressure, age ≥ 65), CORB (confusion, low O2 saturation, respiratory rate, low blood pressure), CRSI-65 (confusion, respiratory rate, shock index, age ≥ 65), SCAP (severe community-acquired pneumonia score), and SMART-COP (systolic blood pressure, multilobar involved on chest x-ray, albumin, respiratory rate, tachycardia, confusion, oxygenation, and pH score). All scoring systems were calculated manually by physician's trained in the use of each score. The assessors were blinded to patient outcomes.

The primary outcome measures studied were in-hospital mortality, ICU admission, need for mechanical ventilation (invasive or non-invasive), and need for vasopressor support. The patients were followed throughout their hospital stay until discharge or death.

Statistical analyses were conducted using IBM SPSS Statistics version 25.0 (IBM Corp., Armonk, NY, USA). Descriptive statistics were used to summarize the data. Continuous variables were reported as means ± standard deviation or medians with interquartile range, depending on the distribution assessed by a Shapiro-Wilk test. Categorical variables were summarized as frequencies and percentages. In order to compare groups, independent t tests or the Mann-Whitney U test were used for continuous variables, while Chi-square or Fisher's exact test were used for categorical variables.

Receiver operating characteristic (ROC) curve analysis was performed to evaluate the diagnostic performance of each severity score in predicting outcomes of interest. The area under the ROC curve (AUC) as well as optimal cut-off values, sensitivity, and specificity were calculated for each score in predicting mortality, ICU admission, the requirement for vasopressors, and mechanical ventilation. A p-value of < 0.05 was considered statistically significant.

This study was conducted according to the ethical guidelines stated in the Declaration of Helsinki, and ethical approval from the Institutional Review Board (IRB) of Aziz Fatimah Hospital, Faisalabad, was obtained according to reference number 87-02-IRB/22. Informed consent was obtained from all study subjects or their legal representatives prior to participating in the research.

Results

The study included a total of 92 patients with community-acquired pneumonia (CAP), with a mean age of 59.6 ± 17 years and 62% male. Of these, 72 (78.3%) were admitted to ICU and there were 20 (21.7%) patients admitted to general wards. As shown in Table 1, patients admitted to ICU were older and had a higher proportion of mechanical ventilation, vasopressors, and death when compared to the patients managed in the ward though this was neither all statistically significant. The ICU patients had a lower proportion of smokers (34.7%, $p = 0.005$) than the ward patients (70.0%). The overall in hospital mortality was 29.3% with a total of 27 deaths during admission. Ventilation was required in 25 patients (27.2%) and vasopressors in 30 patients (32.6%) (Table 1).

Patients admitted to the intensive care unit (ICU) had significantly greater median values across all severity scoring systems compared to patients who were managed in the ward. The median PSI score was significantly greater for patients admitted into the ICU (140 vs 100, $p = 0.001$), as were CURB-65, CORB, CRSI-65, SCAP and SMART-COP scores (all $p < 0.01$). These results further support the use of severity scores in triaging ICU patients who are in need of intensive monitoring and treatment (Table 2).

Non-survivors were consistently higher on all assessment tools than survivors. The median PSI score for non-survivors was 160 (vs 121 in survivors), $p = 0.004$. SCAP had the highest sensitivity (78%) for predicting mortality, while SMART-COP had the highest specificity (98%) for ruling in patients with high-risk of death (Table 3).

Patients requiring vasopressors had significantly higher severity scores, as presented in Table 4. The median SCAP and SMART-COP scores were significantly higher

Table 1. Baseline characteristics of study cases

Variable		Value
Age (years), mean ± SD		58.3 ± 14.7
Male, n (%)		55 (59.8)
Comorbidities, n (%)	Hypertension	40 (43.5)
	Diabetes	32 (34.8)
	COPD	25 (27.2)
Smoking history, n (%)		35 (38.0)
Length of hospital stay (days), median (IQR)		8 (5–12)

in the vasopressor group (SCAP: 25 vs. 19, p = 0.008; SMART-COP: 6 vs. 4, p = 0.002). CORB and SCAP scores had the highest sensitivity (80%) for vasopressor requirement; PSI had the highest specificity (95%).

Severity scores were consistently higher in ventilated patients (n = 25) than non-ventilated patients (n = 67). PSI was the most sensitive predictor for MV requirement (sensitivity = 94.1%) and SMART-COP was the most specific (specificity = 69.8%). All scores were significantly associated with MV requirement ($p < 0.05$).

Figure 1 displays the AUC values for each scoring system when assessing in-hospital mortality and ICU admission. SCAP and SMART-COP had the highest overall discriminative performance for both outcomes (AUC 0.88-0.90 for mortality; AUC 0.87-0.89 for ICU admission), while CORB and CRSI-65 had lower predictive accuracy overall. PSI showed good predictive accuracy predicting mortality; however, it had lower specificity for predicting ICU admission.

Discussion

This study evaluated the predictive value of six common severity scoring systems—PSI, CURB-65, CORB, CRSI-65, SCAP, and SMART-COP—in patients with community-acquired pneumonia (CAP). The study evaluated the six scoring systems in their ability to predict in-hospital mortality, ICU admission, mechanical ventilation (MV), and vasopressor need. Each of the scoring systems demonstrated a statistically significant association with these adverse outcomes, with varying sensitivity and specificity.

For in-hospital mortality, non-survivors also had significantly higher scores for all six severity models. Specifically, SCAP and SMART-COP scores were most prognostic of mortality similar to our more recent findings. Memon et al. (2022) conducted a meta-analysis and found that pooled sensitivity of the SMART-COP was 92% with a pooled specificity of 39% for mortality which is meaningful clinically for prompt risk assessment of highest risk patients in a hospital admission.[13] Liu et al. 2018 also demonstrated an Expanded CURB-65 was more predictive than CURB-65 and PSI, with an AUC of 0.826 for mortality prediction, both studies suggest traditional scores can be improved with additional clinical parameters.[14] Our findings further support these studies as SCAP and SMART-COP captured mortality risk more accurately than more straightforward scores such as

Table 2. Distribution of clinical outcomes in patients with CAP

Outcome	Yes, n (%)	No, n (%)
Mortality	27 (29.3)	65 (70.7)
ICU admission	72 (78.3)	20 (21.7)
Mechanical ventilation	25 (27.2)	67 (72.8)
Vasopressor use	30 (32.6)	62 (67.4)

Table 3. Comparison of severity scores between survivors and non-survivors

Score	Survivors Median (IQR)	Non-survivors Median (IQR)	p-value
PSI	85 (70–100)	120 (105–140)	<0.001
CURB-65	2 (1–3)	4 (3–5)	<0.001
CORB	2 (1–3)	4 (3–5)	<0.001
CRSI-65	2 (1–3)	4 (3–5)	<0.001
SCAP	8 (6–10)	12 (10–14)	<0.001
SMART-COP	4 (3–6)	8 (7–9)	<0.001

CORB or CRSI-65.

Meanwhile, regarding ICU admission, patients admitted to the ICU had much higher severity scores than those who did not. Neither SMART-COP nor SCAP did particularly better because they addressed severity due to including respiratory and hemodynamic status as part of the scoring system. This confirms, once again, the findings of a prospective study by Montull et al. (2016) showing the usefulness of scoring systems that considered oxygenation and multi-lobar pneumonia in identifying patients who require intensive care.[15] Furthermore, an evaluation of severity scores in pneumonia in 2020 found that SMART-COP was better than CURB-65 and PSI for predicting intervention for ICU-level treatment, aligning with our findings in this cohort.[16] These studies further support our data in suggesting CURB-65 and similar traditional scores have limited utility in the critical care space.

For mechanical ventilation, all of the scoring systems came out statistically higher in the ventilated patients compared to the non-ventilated patients. PSI had the highest sensitivity for MV prediction, but SMART-COP had slightly better specificity for locomotor disability. This is in keeping with a study by Abdelkader et al. (2021) that determined SMART-COP to be the best predictor of need for ventilatory support among critically ill patients with CAP.[17] In our investigation of SCAP which also includes the values of the arterial oxygenation and pH, SCAP also had excellent predictive ability over and above the other scoring systems and this is also consistent with a more recent investigation from Latin America linking SCAP scores of more than 10 with both MV requirement and increased mortality risk.[18]

In relation to vasopressor requirement, our analysis showed that SCAP and SMART-COP yet again outperformed other scores, with the highest sensitivity and specificity for predicting circulatory failure and in line with the existing literature. Memon et al. (2022) highlighted SMART-COP's unique inclusion of hypotension and need for fluid resuscitation, which further supports its role in the assessment of a vascular problem requiring vasopressors.[13] Similarly, a prospective cohort study in

Table 4. Receiver operating characteristic (ROC) analysis for mortality prediction

Score	AUC	Sensitivity (%)	Specificity (%)
PSI	0.85	92.6	58.5
CURB-65	0.79	81.5	68.9
CORB	0.77	77.8	70.0
CRSI-65	0.78	80.0	69.2
SCAP	0.88	88.9	80.0
SMART-COP	0.90	92.6	82.3

Table 5. Receiver operating characteristic (ROC) analysis for ICU admission prediction

Score	AUC	Sensitivity (%)	Specificity (%)
PSI	0.82	90.3	60.0
CURB-65	0.80	84.7	65.0
CORB	0.78	82.0	66.0
CRSI-65	0.79	83.3	66.7
SCAP	0.87	88.9	78.0
SMART-COP	0.89	91.7	80.0

China reported that SCAP was the best performing score to predict hemodynamic instability in CAP patients.[19]
CURB-65 and PSI, still the most widely utilized, demonstrated only moderate performance in predicting each of the four outcomes. The Pneumonia Severity Index has impressive and extensive validation and has demonstrated consistent sensitivity for mortality prediction; however, the significant complexity and reliance on laboratory data may make it less applicable in emergency environments as the dominant severity score. CURB-65, while easy to use, risks underestimating severity in young patients or those with subtle respiratory compromise, or when treating a greater proportion of collapsed patients with longer hospital stays, and recent studies have reported that altering CURB-65 (by adding oxygen saturation or adjusting for age) may improve the severity score accuracy.[20,21]
The strengths of this study are that it provides a complete, head-to-head comparison of six tested scoring tools using four objective outcome measures in hospitalized CAP patients. The limitations include performing the study as a single-center cohort, the relatively small size of the sample, and that long-term outcomes such as 30-day mortality and readmission were not reported. Also, newer

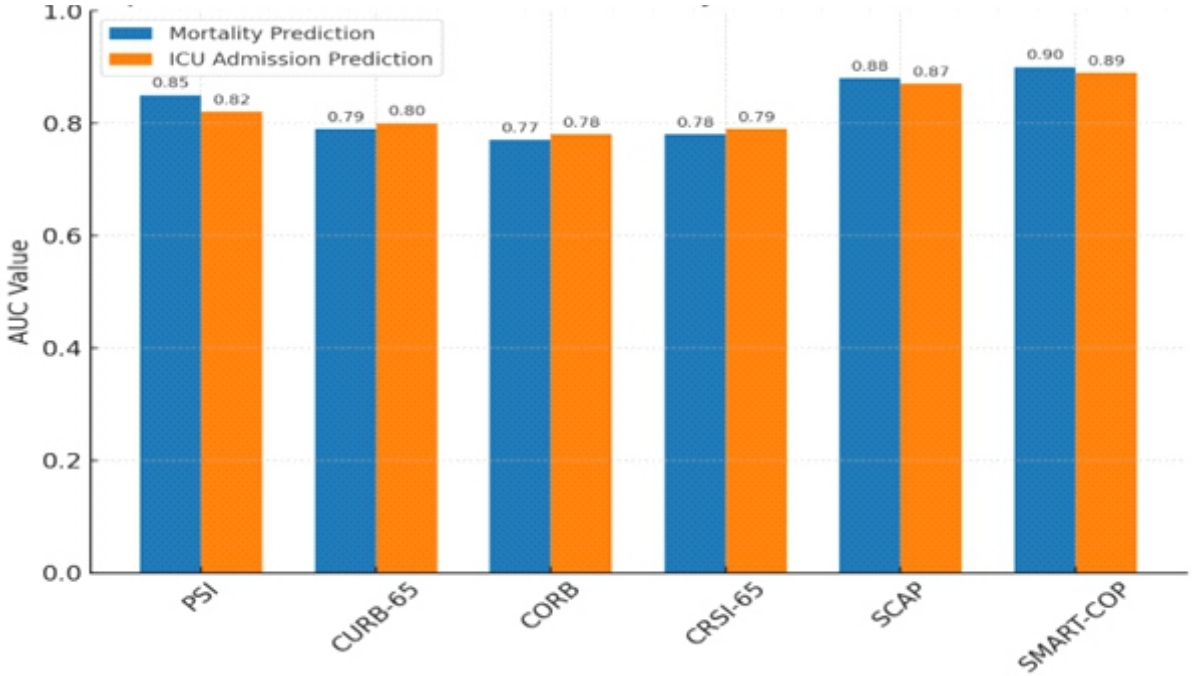

Figure 1. Comparison of AUC values for mortality and ICU admission prediction

predictive models, such as Expanded CURB-65 and machine-learning–based predictive algorithms, were not evaluated and may provide better accuracy in future studies.

Conclusion

This research study provides important information about understanding which of the six severity scoring systems (PSI, CURB-65, CORB, CRSI-65, SCAP, and SMART-COP) is more accurate in predicting clinically important outcomes in patients with community-acquired pneumonia. Among the six systems evaluated, both SCAP and SMART-COP had a consistently higher sensitivity and specificity in their ability to identify patients at risk for in-hospital mortality, ICU admission, need for mechanical ventilation, and/or use of vasopressors. While PSI was very sensitive for predicting mortality overall, it was not an effective tool for fast triage more so because it was too complicated requiring multiple calculations. CURB-65 and CORB also produced moderate predictive values overall, but in practice may be limited in identifying early deterioration in critically ill patients. Thus, the evaluative study supports SCAP and SMART-COP as more useful instruments to provide useful risk stratification in acute care environments. Integrating SCAP and SMART-COP scores into clinical practice can facilitate not only the early identification of high-risk patients. It can allow for better utilization of clinical services, and improve patient oriented outcomes. The evaluative data suggests further multicenter, large-scale studies to validate these results, and to test their feasibility in many different healthcare environments.

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