Comparison of APACHE-II, SAPS and SOFA as the best predictor of mortality among critically ill patients.

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ABSTRACT:

Objective: To find out the predictive ability of various scoring system including APACHE II, SOFA and SAPS II in finding the prognosis of critically ill patients.

Methodology: This cross-sectional study was conducted at Medical and Surgical intensive care units (ICU) and High dependency units, Dow University of Health Sciences Karachi Pakistan, from January 2025 to June 2025.. A total of 198 patients, aged 18-80 years, were recruited from the high dependency units, medical and surgical intensive care units. These patients diagnosed with sepsis after presenting with a serious condition. Vital signs, the GCS score, and a systematic examination were used to evaluate the patients. Within 24 hours after admission, APACHE II, SAPS II, and SOFA scores were assessed. Patients' outcome at discharge was recorded and compared with predicted mortality by these scoring systems.

Results: Out of 198 patients, 89 (44.9%) did not survive. The mean APACHE-II score (19.13±3.65 vs. 26.33±2.74), SAP-II score (34.45±8.39 vs. 47.21±0.92) and SOFA score (7.27±2.07 vs. 11.00±1.26) were markedly elevated among non-survivors than survivors. SAPS II score showed the highest discriminatory power on ROC analysis (AUROC=0.979) followed by APACHE II score (AUROC=0.941) and SOFA score (AUROC=0.904).

Conclusion: The three prognostic scores (APACHE II, SAPS II, and SOFA) showed adequate accuracy in predicting mortality among critically ill patients with sepsis. Among them, SAPS II showed superior calibration and discriminatory power compared with APACHE II and SOFA.

Keywords: Critical illness, intensive care units, sepsis, mortality. APACHE II, SOFA, SAPS II

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Introduction:

One of the most challenging diseases to treat in critically ill patients is sepsis. Sepsis is correlated with a significant risk of fatalities despite substantial breakthroughs in intensive care management.[1, 2] According to available global statistics, sepsis affected nearly 49 million people in 2017, with about 11 million deaths.[3] Despite advancement in medical field that effectively decrease the number of sepsis cases globally, it still responsible for approximately 20% of deaths worldwide, which equates to more than 20 fatalities each minute.[3, 4] The prognosis of critically ill patients is highly impacted by a number of factors, such as the timing of diagnosis, the effectiveness of antibiotic therapy, and the extent of organ dysfunction. Early identification and immediate initiation of sepsis bundles in critically ill patients have been demonstrated to enhance survival, but fatality rates remain high, especially among patients who progress to septic shock. Among the patients who require intensive care unit (ICU) admission, different severity scoring systems are formulated to evaluate patients' status of diseases and their prognosis. Clinical severity scores are increasingly being used alongside clinical and laboratory parameters to improve risk stratification and assist physicians in making treatment decisions. These systems may be used to compare actual mortality with predicted mortality.[5-7]

Some of the most commonly used severity scoring systems include the Sequential Organ Failure Assessment (SOFA), the Acute Physiology and Chronic Health Evaluation II (APACHE II), and the Simplified Acute Physiology Score II (SAPS II). These severity scoring systems are used in the routine assessment of a patient's condition as well as for predicting the progression of diseases and the risk of mortality.[8, 9] The data for these severity scores are obtained within the first 24 hours of admission for better prediction and management. The risk of death in the hospital increases with high severity score. All versions of the APACHE (II-IV) and SAPS (II and III) scoring systems are prognostically accurate, but the earlier models of both systems are still regarded as the gold standard. However, the heterogeneity and complexity of sepsis limit the prognostic reliability of a single score.[8-10] The rationale of this study is to compare the various scoring systems, including APACHE II, SOFA and SAPS II, in forecasting death in order to pick up sepsis at an early stage and bring down the morbidity and mortali-

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ty and, as a result, help to reduce the healthcare cost. Data on sepsis and the accuracy of severity scoring systems in Pakistan are unfortunately very limited, so this study will contribute to generating local data and improving patient management.

Methodology:

From January to June 2025, this cross-sectional study was carried out at Dow University of Health Sciences' medical and surgical intensive care units (ICU) and high dependency unit in Karachi, Pakistan. The study includes patients of either gender having sepsis and critically ill, aged between 18 and 80 years admitted to medical and surgical ICUs and high dependency units for more than 24 hours. APACHE II, SOFA, and SAPS II scores were calculated. We excluded all those patients admitted to medical wards, unwilling to provide written consent, patients with do-not-resuscitate order and those receiving solely palliative care

The sample size was estimated using Open Epi software, based on the mortality proportion of 35.4% reported by Naqvi et al.[11] With a 95% confidence interval, 7% margin of error, and 10% drop-out, the required sample size was calculated to be 198. Participants were recruited using the consecutive sampling technique.

This study was carried out with permission from the Dow University Hospital's Institutional Review Board (IRB) in Karachi (Letter No. IRB-3773/DUHS/Approval/2024/22, dated 15 January 2025). All eligible participants gave written informed consent before enrolling for the study. A brief demographic history, including age, and gender, along with the duration of illness and past comorbidities on the basis of history (such as diabetes, hypertension, chronic kidney disease, malignancy, ischemic heart disease, and heart failure), was obtained. Patients were assessed for vital signs, Glasgow Coma Scale (GCS) score, and systemic examination. Relevant blood investigations were performed, and APACHE II, SAPS II, and SOFA scores were measured within 24 hours after being admitted to the ICU. The patients' outcomes at discharge was documented and compared with the mortality predicted by these scoring systems recorded earlier.

Critically ill patients were those who experiencing severe medical conditions or injuries making them susceptible to imminent death or vital organ dysfunction, necessitating intensive care. Sepsis diagnosis was confirmed on SIRS criteria. The efficacy was the potential of the three predictive scores to accurately forecast the likelihood of death. Mortality was predicted using the following cutoffs: APACHE II ≥22, SAPS II ≥46, and SOFA ≥9. Final outcome was compared between survivors and non-survivors. Those who received treatment in hospital and discharge alive were considered survivors, whereas non-survivors were those who died during the hospital stay.

Statistical Package for Social Science (SPSS) software version 26 was used for Statistical analysis. A 2×2 table was constructed to compare predicted and observed mortality across the severity scoring systems. The diagnostic accuracy of all three scores were assessed by calculating sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and overall accuracy. Receiver operating characteristic (ROC) curve analysis was performed for each scoring system to evaluate discriminative ability, and the area under the curve (AUC) was calculated. Optimal cut-off values of severity scores were established using ROC curve analysis in SPSS. The Youden's Index was utilized to determine the best cutoff for each scoring system in predicting mortality by balancing sensitivity and specificity. The Youden model's relevant cut-off points were then used for additional analysis and comparison. For all statistical tests, the significance threshold was set at 0.05.

Results:

Results of the 198 critically ill patients diagnosed with sepsis, 59.6% (n=118) were male, while 40.4% (n=80) were female. The overall mean age was 62.08±13.74 years, while non-survivors were older than survivors (67.72±11.80 vs. 57.48±13.55 years). The mean duration of illness was also significantly higher in non-survivors (10.03±3.25 days) as compared to survivors (5.49±3.04 days). Non-survivors had a significantly higher frequency of all reported comorbidities compared to survivors [Table 1].

Table 1: Demographics and Clinical Characteristics in Critically Ill Patients (n=198)

Variables		Outcome			P Value
		Survivors (n=109)	Non-Survivors (n=89)	Total (n=198)	
Gender	Male	69 (63.3%)	49 (55.1%)	118 (59.6%)	0.239
	Female	40 (36.7%)	40 (44.9%)	80 (40.4%)	
Age (Years)	Mean ±SD	57.48 ±13.55	67.72 ±11.80	62.08 ±13.74	<0.001
	18-40	19 (17.4%)	0 (0.0%)	19 (9.6%)	<0.001
	41-60	40 (36.7%)	19 (21.3%)	59 (29.8%)	
	61-80	50 (45.9%)	70 (78.7%)	120 (60.6%)	
Duration of illness (Days)	Mean ±SD	5.49 ±3.04	10.03 ±3.25	7.53 ±3.86	<0.001
DM	Yes	30 (27.5%)	70 (78.7%)	100 (50.5%)	<0.001
	No	79 (72.5%)	19 (21.3%)	98 (49.5%)	
HTN	Yes	40 (36.7%)	79 (88.8%)	119 (60.1%)	<0.001
	No	69 (63.3%)	10 (11.2%)	79 (39.9%)	
CKD	Yes	18 (16.5%)	62 (69.7%)	80 (40.4%)	<0.001
	No	91 (83.5%)	27 (30.3%)	118 (59.6%)	
Malignancy	Yes	3 (2.8%)	17 (19.1%)	20 (10.1%)	<0.001
	No	106 (97.2%)	72 (80.9%)	178 (89.9%)	
IHD	Yes	10 (9.2%)	49 (55.1%)	59 (29.8%)	<0.001
	No	99 (90.8%)	40 (44.9%)	139 (70.2%)	

The mean APACHE-II score (19.13±3.65 vs. 26.33±2.74), SAP-II score (34.45±8.39 vs. 47.21±0.92) and SOFA score (7.27±2.07 vs. 11.00±1.26) were markedly elevated among non-survivors than survivors [Table 2].

Table No 2: Mean Severity Scores in Critically Ill Patients (n=198)

Severity Scores	Survivors (N=109)	Non-Survivors (n=89)	Total (N=198)	p value
APACHE-II	19.13 ±3.65	26.33 ±2.74	22.36 ±4.85	<0.001
SAPS-II	34.45 ±8.39	47.21 ±0.92	40.19 ±8.91	<0.001
SOFA	7.27 ±2.07	11.00 ±1.26	8.94 ±2.55	<0.001

After using a cut off score of ≥22 for APACHE-II, 100 critically ill patients were predicted to survive, and 98 were predicted to die. Of the 100 critically ill patients predicted to survive, 90 survived, while 10 died. Among the 98 critically ill patients predicted to die, 79 died while 19 survived [Table 3].

Table No 3: A 2×2 Table For Predicted and Observed Mortality by Severity Scores in Critically Ill Patients (n=198)

		Outcome		Total
		Survivors (N=109)	Non-Survivors (n=89)	
APACHE-II	Survivors	90	10	100
	Non-Survivors	19	79	98
SAPS-II	Survivors	109	10	119
	Non-Survivors	0	79	79
SOFA	Survivors	99	10	109
	Non-Survivors	10	79	89

The calculated sensitivity, specificity, PPV, NPV, and diagnostic accuracy for the APACHE II score in predicting mortality were 100.0%, 82.6%, 82.4%, 100.0% and 90.4%, respectively [Table 4].

Table No 4: Accuracy of Severity Scores in Critically Ill Patients (n=198)

Parameters	APACHE-II	SAPS-II	SOFA
Sensitivity	100.0%	88.8%	88.8%
Specificity	82.6%	100.0%	90.8%
Positive Predictive Value	82.4%	100.0%	88.8%
Negative Predictive Value	100.0%	91.6%	90.8%
Diagnostic Accuracy	90.4%	94.9%	89.9%

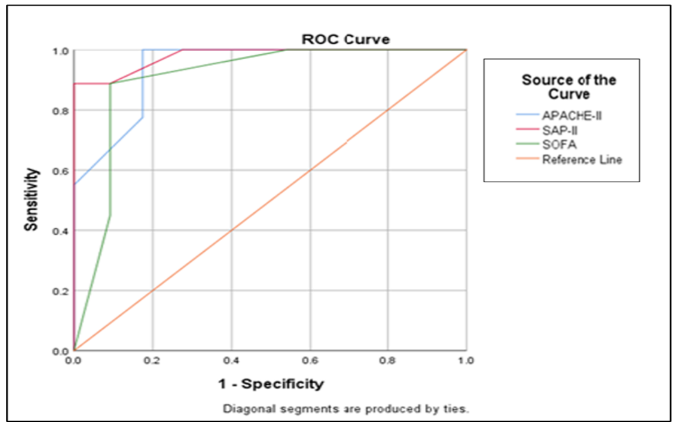
After using a cut off score of ≥46 for SAPS-II, 119 critically ill patients were predicted to survive, and 79 were predicted to die. Of the 119 critically ill patients predicted to survive, 109 survived, while 10 died. Among the 79 critically ill patients predicted to die, 79 died while 0 survived [Table 3]. The calculated sensitivity, specificity, PPV, NPV, and diagnostic accuracy for the SAPS-II score in predicting mortality were 88.8%, 100.0%, 100.0%, 91.6% and 94.9%, respectively [Table 4]. After using a cut off score of ≥9 for SOFA, 109 critically ill patients were predicted to survive, and 89 were predicted to die. Of the 109 critically ill patients predicted to survive, 99 survived, while 10 died. Among the 89 critically ill patients predicted to die, 79 died while 10 survived [Table 3]. The calculated sensitivity, specificity, PPV, NPV, and diagnostic accuracy for the APACHE II score in predicting mortality were 88.8%, 90.8%, 88.8%, 90.8% and 89.9%, respectively [Table 4].

SAPS II score showed the highest discriminatory power on ROC analysis (AUROC=0.979) followed by APACHE II score (AUROC=0.941) and SOFA score (AUROC=0.904) [Table 5 and Figure 1].

Table No 5: Area Under Curve of Severity Scores in Critically Ill Patients (n=198)

Model	AUC	Standard Error	95% CI	P-Value
APACHE-II	0.941	0.015	0.912-0.971	<0.001
SAPS-II	0.979	0.008	0.965-0.994	<0.001
SOFA	0.904	0.024	0.857-0.950	<0.001

Figure No 1: ROC Curve of Severity Scores on prediction of mortality in Critically Ill Patients.



Discussion::

This study evaluated the predictive ability of three prognostic scores (APACHE II, SOFA, and SAPS II) in assessing the mortality among critically ill patients. All three models demonstrated acceptable calibration and discrimination in predicting mortality among critically ill patients diagnosed with sepsis. Among them, SAPS II showed superior calibration and discriminatory power compared with APACHE II and SOFA. In this study, mortality was 44.9% among critically ill patients, which is comparable with previous studies from Pakistan (35.4% to 52.7%), India (48.0% to 51.0%), and Turkey (41.0% to 63.5%). The high mortality burden in critically ill patients diagnosed with sepsis is due to a variety of reasons, including delayed identification, late ICU admission, limited ICU resources, high prevalence of comorbidities, greater disease severity, and multidrug-resistant infections.[11-16]

In this study, the majority of patients were male 59.6% (n=118), while 40.4% (n=80) were female, with no significant difference (p=0.239) between survivors and non-survivors. The overall mean age was 62.08±13.74 years; however, non-survivors were significantly older than survivors (67.72±11.80 vs. 57.48±13.55 years, p<0.001). Similar demographics were reported in previous studies, such as Mehta et al. who reported 69% male and 31% female patients with an overall mean age of 56.71±16.77 years; however, non-survivors were significantly older than survivors (59.48±15.54 vs. 53.81±16.13 years, p<0.05).[13] Cirik et al. who reported 66.7% male and 33.3% female patients with mean age of 70.38±15.85 years.[16] Ranjit et al. who reported 62% male and 38% female patients with mean age of 57.07±14.4 years.[17] The higher sepsis burden and mortality in critically ill patients among males and older individuals is due to several factors, including weaker immune responses, decline in immunity with age, and a higher incidence of comorbidities.

In this study, the prevalence of comorbidities was high, including diabetes mellitus (50.5%, n=100), hypertension (60.1%, n=119), CKD (40.4%, n=80), IHD (29.8%, n=59), and malignancy (10.1%, n=20). Non-survivors had a significantly higher frequency of all reported comorbidities compared to survivors. Similar studies have also reported a high prevalence of comorbidities such as diabetes, hypertension, CKD, and CVD among critically ill patients diagnosed with sepsis, and these were consistently associated with poor outcomes as well as with higher mortality[18, 19].

In this study, the significantly higher APACHE II, SAPS II, and SOFA scores observed in non-survivors compared with survivors indicating the significant prognostic importance of these severity scores in estimating mortality among critically ill patients. Similar studies have also reported higher APACHE II, SAPS II, and SOFA scores in non-survivors compared with survivors. This difference in severity scores reflects the delayed identification, advanced disease, and higher organ dysfunction among critically ill patients with sepsis, all of which are associated with poor outcomes as well as with higher mortality[11, 13-17].

In this study, an APACHE II score ≥22, a SAPS-II score ≥46, and a SOFA score ≥9 were used for predicting mortality. The sensitivity was highest with APACHE II, while the specificity was highest with SAPS II (both 100%). Similarly, the PPV was highest with SAPS II, while the NPV was highest with APACHE II (both 100%). Overall diagnostic accuracy was greatest with the SAPS II scoring system (94.9%), followed by APACHE II (90.4%) and SOFA (89.9%).

Similar studies have also reported comparable accuracy of APACHE II, SAPS II, and SOFA scores in identifying the risk of mortality. Furqan et al. reported markedly elevated sensitivity (77.53%), specificity (94.28%), and accuracy (85.45%) with the APACHE II score[12]. Tekin et al. reported higher sensitivity (77.1%) with the APACHE II score and higher specificity (73.9%) with the SOFA score[15]. Sharma et al. reported that sensitivity was highest with APACHE II (100%), whereas specificity was highest with SAPS II and SOFA (both 100%). Similarly, the PPV was highest with SAPS II and SOFA (both 100%), while the NPV was highest with APACHE II (100%)[20]. The findings suggest that APACHE II is particularly effective for identifying patients at lower risk of death, while SAPS II and SOFA are more accurate in confirming those at higher risk. This indicates that applying these scoring systems together may enhance the precision of mortality prediction in critically ill sepsis patients with sepsis.

In this study, ROC curve analysis was performed for each scoring system to evaluate their discriminative ability, and the AUC was calculated. Optimal cut-off values of severity scores were also established using ROC analysis. Among the three scoring system, SAPS II score showed the highest discriminatory power on ROC analysis (0.979) followed by APACHE II score (0.941) and SOFA score (0.904). Similar studies have also reported comparable AUC of prognostic scores in identifying the risk of mortality among critically ill patients with sepsis. Naqvi et al. reported AUC values of 0.835, 0.75 and 0.75 for the APACHE II, SOFA, and SAPS II score, respectively[11]. Mehta et al. reported AUC values of 0.64, and 0.54 for the APACHE II and SOFA score, respectively[13]. Tekin et al. reported AUC values of 0.784, 0.802 and 0.780 for the APACHE II, SOFA, and SAPS II score, respectively[15]. Cirik et al. reported AUC values of 0.803, 0.873 and 0.902 for the APACHE II, SOFA, and SAPS II score, respectively[16]. The findings suggest that all three scoring systems (APACHE II, SAPS II, and SOFA) showed adequate accuracy in predicting mortality among critically ill patients with sepsis. Among them, SAPS II showed superior calibration and discriminatory power compared with APACHE II and SOFA.

This cross-sectional study carries certain limitations. Firstly, the study design restricts the ability to evaluate changes in severity scores over time, as data were collected at a single point. Secondly, the limited sample size and single-center setting reduce the extent to which these findings can be applied to broader populations. Finally, unmeasured factors such as ICU resources, appropriateness of antibiotics, treatment practices, and patient-related characteristics may also have influenced the outcomes.

Conclusion:

The three prognostic scores (APACHE II, SAPS II, and SOFA) showed adequate accuracy in predicting mortality among critically ill patients with sepsis. Among them, SAPS II showed superior calibration and discriminatory power compared with APACHE II and SOFA.

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Authors' Contribution	
Syeda Areeba Shirazi	conception and design, acquisition of data, analysis, and interpretation of data.
Darshan Kumar	Drafting manuscript, shared expert opinion and experience in finalizing the manuscript.
Afshan Siddique	Collection and acquisition of data and help in analysis and review of manuscript
Salma Salman	Contributed to conception and interpretation of data.
Qutab Uddin	Final proofreading, review of literature, grammatical review.