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A Study To Compare Combination Of Modified Early Warning Score (Mews) And Lactate With Sequential Organ Failure Assessment (Sofa) Score And Acute Physiology And Chronic Health Evaluation (Apache) Ii Score In Predicting Severity In Sepsis Patients

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Abstract:
The hallmark of sepsis, a complicated clinical condition that can lead to potentially fatal organ failure, is a dysregulated host response to infection. [1] When the body's reaction to an infection damages its own tissues and organs, sepsis results. If left untreated, sepsis can result in septic shock and multi-organ failure. Globally, sepsis remains a major public health challenge, accounting for significant morbidity and mortality, and is currently recognized as one of the leading causes of death worldwide, ranking as the tenth most common cause.[2] Sepsis is more common in low- and middle-income nations because of a lack of funding and delayed access to medical care. Studies have demonstrated that delays in diagnosis and treatment greatly raise the risk of death for individuals with sepsis, making early detection and prompt intervention essential.

INTRODUCTION

The pathophysiology of sepsis is intricate, involving a cascade of immune responses to an infectious trigger. When the body encounters a pathogen, an exaggerated inflammatory reaction ensues, marked by excessive release of pro-inflammatory cytokines—a phenomenon often referred to as a "cytokine storm."[3] This dysregulated immune response leads to widespread endothelial damage, microcirculatory dysfunction, and impaired oxygen delivery to tissues.[4] As a result, cellular metabolism becomes deranged, often reflected by elevated lactate levels due to anaerobic metabolism, which serves as an important marker of tissue hypoperfusion. If left unchecked, these pathophysiological processes drive the progression from sepsis to septic shock and, ultimately, multi-organ disfunction syndrome (MODS), contributing to poor clinical outcomes.[5]

Accurate and timely prognostication is essential due to sepsis's high mortality and quick progression. Various clinical scoring systems have been developed to assess the severity of illness and predict outcomes in critically ill patients. Among these, the Modified Early Warning Score (MEWS) is a straightforward bedside measure that predicts in-hospital mortality and ICU admissions based on physiological markers that are easily measurable.[6] Meanwhile, the SOFA[7] and the APACHE II[8] scores are more comprehensive, incorporating laboratory data and detailed clinical information to quantify organ dysfunction and disease severity. While these tools are well-established in critical care settings, they may be resource-intensive and time-consuming, especially in settings where rapid decisions are needed.

However, there is growing interest in whether combining simple bedside assessments like MEWS with readily available biomarkers such as lactate can provide an effective alternative for early prognostication in sepsis. Lactate is frequently used to gauge the severity of the illness and direct resuscitation because it is a well-known indicator of tissue hypoperfusion and metabolic stress in sepsis. A combination of MEWS and lactate may offer a practical, cost-effective, and rapid method of assessing the severity of sepsis, particularly in resource-limited environments. Currently, there is a lack of studies directly comparing this combination with more established scores like SOFA and APACHE II in predicting outcomes in sepsis patients. Therefore, this study aims to fill that gap and evaluate whether the combination of MEWS and lactate can match or surpass traditional scoring systems in prognostic accuracy.

Improved methods of early risk stratification in sepsis are essential not only for guiding clinical decisions but also for optimizing resource allocation and improving patient outcomes. By comparing the combination of MEWS and lactate with SOFA and APACHE II, this study seeks to identify a simple, effective prognostic tool that could potentially enhance bedside assessment of sepsis severity, aid in timely interventions, and provide valuable insights for future research in the ongoing quest to reduce the global burden of sepsis.

MATERIALS AND METHODS

Aim

To prognosticate the severity and outcome of patients with sepsis based on Combination of Modified Early Warning score with lactate, in comparison with SOFA and APACHE II scores.

Study Design and Setting: This was a prospective observational study, conducted on patients who presented to the Emergency Medicine Department (EMD) of R. L. Jalappa Hospital and Research Centre with sepsis as per SIRS criteria.

Study Population: Patients who presented to the Emergency Medicine Department (EMD) of R. L. Jalappa Hospital and Research Centre with sepsis meeting diagnostic criteria according to SIRS and age more than 18 years. Excluded, patients with hepatic, renal, or cardiac disorders with decompensation, pregnant women with sepsis, and patients who were admitted and treated outside the study facility for more than 24 hours prior to inclusion.

Method of Data Collection:

All patients who fulfilled the inclusion criteria were enrolled in the study after obtaining written informed consent from the patient or their legally authorized representative. A structured proforma was employed to systematically document each patient's demographic details, hemodynamic parameters, laboratory investigations, example: CBC, RFT, LFT, Serum lactate, Blood or urine cultures, etc (essential for confirming the diagnosis of sepsis, identifying the source of infection, assessing organ dysfunction, and calculating severity scores). Once the clinical examination and investigations were completed, the scores were calculated for each patient. For each patient, the following outcome data were collected during follow-up: Total number of days the patient required mechanical ventilation, if applicable, duration of ICU stay (in days),duration of hospital stay (in days), final outcome of the patient: whether they were discharged in a stable condition or whether they expired during the hospital stay.

Statistical Methods:

Based on a difference in sensitivity between APACHE II (83%) and MEWS (76%), with an alpha error of 5% and a power of 80%, the estimated sample size was calculated as 94. Considering a 5% dropout rate, the final sample size was set at 100.

Sample size calculation was performed using G*Power version 3.1.9.7 software.

The collected data were entered into Microsoft Excel and analysed using Statistical Package for the Social Sciences (SPSS), version 2022. Categorical variables were presented as frequencies and percentages. Continuous variables were expressed as mean ± standard deviation. The Chi-square test was applied to compare categorical variables. Graphs and visual data presentations, including bar diagrams, pie charts, and ROC curves, were created using MS Excel and MS Word. A p-value < 0.05 was considered statistically significant.

RESULTS

Most patients (43.8%) were aged 41–60 years, indicating that middle-aged individuals formed the largest group in the study. Only 19.9% were below 40 years. There were more male patients (61.2%) than female patients in this study, suggesting a possible gender disparity in sepsis presentation or admission. Respiratory infections were the most commonly known source of sepsis (23.9%), closely followed by unknown causes (22.9%), suggesting diagnostic challenges or multiple sepsis origins.

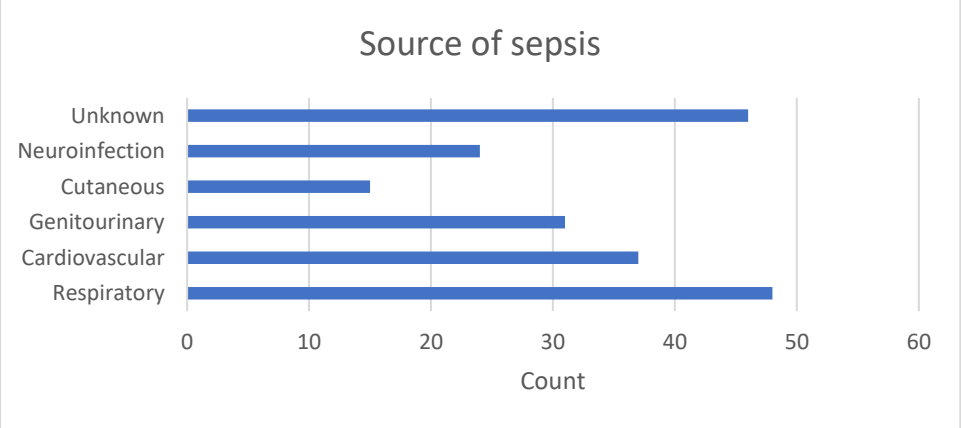

Figure1: Source of Sepsis

Most patients (56.2%) had a GCS score of 15, indicating full consciousness on presentation. Only 10% had a GCS ≤8, suggesting more severe neurologic compromise in a minority. Most patients (78.1%) were discharged, whereas 21.9% died during hospitalization. This serves as the primary outcome variable for assessing predictive scores like MEWS, Lactate, SOFA, and APACHE II.

Table1: Discharge vs Death Status

Outcome	Frequency	Percent (%)
D (Discharged)	157	78.1
M (Mortality / Deceased)	44	21.9
Total	201	100.0

Table2: Association of Clinical Scores with Outcome (Expired vs Discharged)

Variable	Expired (M)Mean ± SD	Discharged (D)Mean ± SD	Mann–Whitney Up-value	Interpretation
MEWS	8.02 ± 2.12	5.38 ± 1.85	< 0.001	Significantly higher in mortality group
SOFA	10.77 ± 2.70	6.54 ± 2.46	< 0.001	Strong association with death outcome
APACHE II	29.48 ± 6.97	15.19 ± 6.82	< 0.001	Most distinct score between groups
Lactate	10.97 ± 5.02	5.20 ± 2.78	< 0.001	Elevated lactate linked to higher mortality
MEWS + Lactate	18.99 ± 5.80	10.58 ± 3.65	< 0.001	Strong composite predictor of poor outcome

All clinical scores and lactate values were significantly higher among patients who expired ($p < 0.001$ for all comparisons). This confirms a strong association between elevated scores and in-hospital mortality, validating their utility for severity stratification in sepsis.

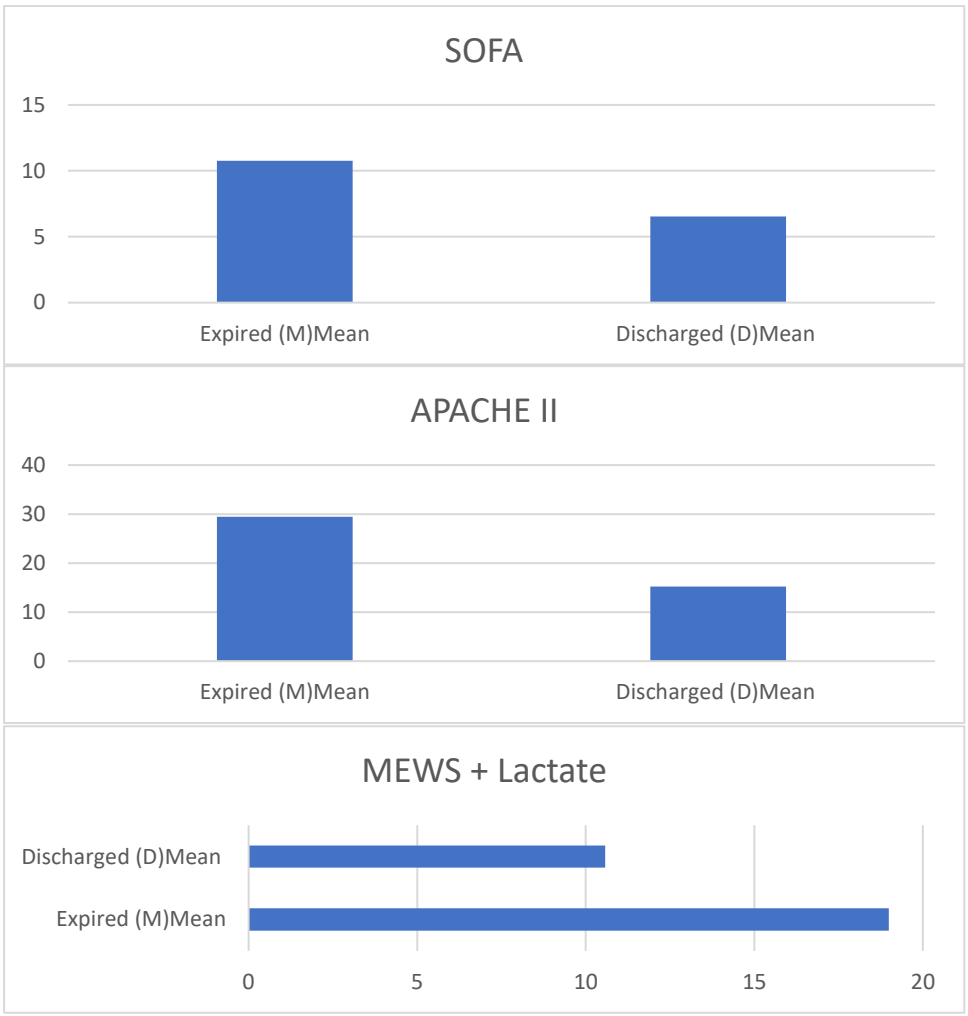

Figure 2: Clinical Scores with Outcome

Table 3: Spearman's Correlation Between Outcome and Clinical Scores

Variable	Correlation with Outcome (DIS/DECEASED)	Direction	Strength	p-value	Interpretation
MEWS	-0.468	Negative	Moderate	< 0.001	Higher MEWS is moderately associated with mortality
SOFA	-0.539	Negative	Moderate	< 0.001	Stronger association with death
APACHE II	-0.601	Negative	Strong	< 0.001	Strongest individual correlation with outcome
Lactate	-0.474	Negative	Moderate	< 0.001	Elevated lactate moderately associated with mortality
MEWS + Lactate	-0.549	Negative	Moderate–Strong	< 0.001	Composite score correlates better than MEWS alone

APACHE II has the strongest individual correlation with outcome. MEWS + Lactate shows slightly stronger correlation than MEWS or lactate alone.

Table 4: Predictive Performance of Scores

Scoring System	AUC	95% CI	Sensitivity	Specificity	Interpretation

APACHE II	0.920	0.870 – 0.969	90%	87%	Excellent predictor; highest discriminative power
MEWS + Lactate	0.883	0.818 – 0.949	88%	80%	Strong composite predictor, better than MEWS alone
SOFA	0.873	0.815 – 0.932	85%	79%	Strong predictor, slightly less than MEWS+Lactate and APACHE

APACHE II performs the best overall, with the highest AUC, sensitivity, and specificity. MEWS + Lactate is a close second, offering strong clinical utility. SOFA, while slightly lower, still shows excellent prognostic value.

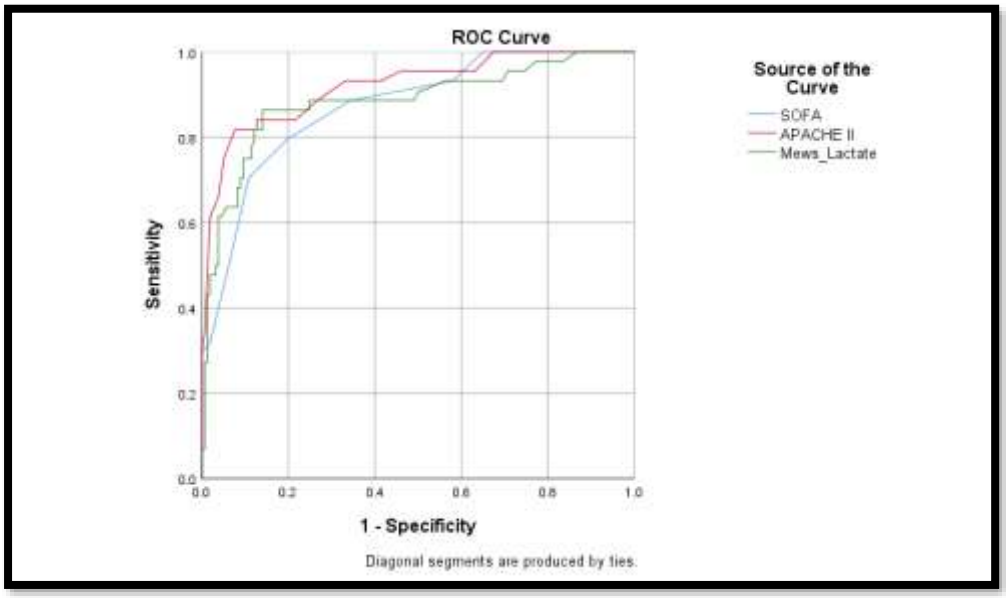

Figure 3: ROC Curve of SOFA, APACHE II and Combination of MEWS and Lactate Score

Table 5: Kruskal-Wallis Test Summary (Overall Group Differences)

Source of Sepsis	MEWS	SOFA	APACHE II	LACTATE	MEWS + Lactate
Respiratory	6.17 ± 2.08	6.53 ± 2.56	18.11 ± 6.99	4.93 ± 2.76	11.10 ± 4.09
Cardiovascular	5.03 ± 1.83	6.95 ± 2.82	16.38 ± 7.52	5.53 ± 1.88	10.55 ± 2.84
Genitourinary	6.06 ± 2.11	7.39 ± 3.77	17.52 ± 11.77	7.27 ± 5.20	13.33 ± 6.84
Cutaneous	5.73 ± 2.09	7.40 ± 2.59	16.33 ± 9.24	5.88 ± 3.97	11.62 ± 5.54
Neuroinfection	6.63 ± 2.04	8.79 ± 2.04	20.33 ± 7.75	6.99 ± 4.27	13.62 ± 4.92
Unknown	6.17 ± 2.59	8.26 ± 3.47	20.28 ± 10.33	8.18 ± 5.14	14.35 ± 6.72
P-value	0.092	0.006	0.275	0.017	0.061

SOFA Score: p = 0.006, There is a significant difference in SOFA scores between at least one pair of sepsis sources. The highest means are in neuroinfection (8.79) and Unknown (8.26). Lactate Levels: p = 0.017, Significant difference. Highest in Unknown (8.18) and Genitourinary (7.27). MEWS+ Lactate: p = 0.061, Not quite significant, but suggestive of group differences; again, unknown and neuroinfection have higher values. APACHE II and MEWS: No significant differences found, but neuroinfection and Unknown have numerically higher means.

The analysis revealed that all three scores were markedly elevated in patients who did not endure, confirming their strong association with mortality. Among them, APACHE II demonstrated the highest discriminative power, with the highest AUC (0.920), sensitivity (90%), and specificity (87%), making it the most reliable standalone predictor in this cohort.

The combined MEWS + Lactate score also performed impressively (AUC = 0.883), highlighting its practicality as a rapid bedside tool with good accuracy. SOFA, while slightly less predictive than the other two, still exhibited excellent performance (AUC = 0.873) and remains valuable for organ dysfunction assessment.

Correlation analysis supported these findings, showing strong negative correlations between each score and outcome, particularly for APACHE II and MEWS + Lactate.

- APACHE II is the most accurate predictor of mortality.
- MEWS + Lactate provides a reliable, quick, and practical alternative for early bedside use.
- SOFA remains an effective and comprehensive measure for ICU settings (least preferred).

DISCUSSION

The study demonstrates, the mean age of the study patients was 55.04 (SD 14.97, [20–88]). Most were aged 41–60 years (43.8%) followed by 61+ years (36.3%) and 20–40 years (19.9%). Such distribution is consistent with epidemiological patterns because sepsis occurs more often in patients between the ages of 16 and 80 years as a result of age-related decline of immune function, comorbidity burden, and physiological reserve[9]. There was male preponderance in the cohort with 61.2% and female 38.8% indicating a gender bias on sepsis presentation or admission. This is in line with the literature which indicates a male predominance in the incidence of sepsis, which may be associated with occupational exposure or behavioural elements (e.g. smoking, alcohol use) or differing genetic patterns in immune response [10]. Respiratory infections' leading trigger status is seen worldwide, namely pneumonia, as a key cause of sepsis, especially in the community-acquired setting.[11] we reported a high rate of unknown sources which may be explained by diagnosis difficulty, as secondary to late presentation, atypical clinical course and limited microbiological tests.[12] Distribution of sources may influence outcome predictions, with neuroinfection and unknown origins showing elevated SOFA and lactate levels, suggesting greater severity.[13] Central nervous system involvement or unidentified pathogens may drive worse outcomes, supporting the need for advanced diagnostics like metagenomic sequencing.[14] APACHE II demonstrated the highest prognostic accuracy (AUC 0.920, sensitivity 90%, specificity 87%), stemming from its comprehensive inclusion of 12 physiological variables, age, and chronic health conditions.[15] APACHE II's complexity limits bedside applicability, a limitation noted in resource-constrained settings. [16] Simplifying APACHE II while preserving accuracy, potentially through machine learning, could enhance its utility.[17] The MEWS + Lactate combination yielded an AUC of 0.883 (sensitivity 88%, specificity 80%), positioning it as a strong composite predictor. The moderate-to-strong negative correlation ($r = -0.549$, $p < 0.001$) suggests that lactate—a marker of tissue hypoperfusion—enhances MEWS's prognostic utility. This combination's simplicity, requiring vital signs and a single lactate measurement, supports its use in emergency settings, particularly in low-resource contexts.[11] The borderline significance of MEWS + Lactate ($p = 0.061$) and lack of significance for APACHE II and MEWS ($p = 0.275$ and 0.092) indicate lower sensitivity to source-specific variations.[18] Respiratory sepsis showed moderate scores, reflecting its commonality but variable severity.[19]

APACHE II's superior performance underscores its role as a gold standard in ICU settings, particularly where comprehensive data collection is feasible.[15] Its high sensitivity and specificity support risk stratification.[20] MEWS + Lactate offers a rapid, practical alternative for emergency departments, especially in low-resource settings.[21] SOFA's strength in assessing organ failure makes it invaluable for ICU management, with potential enhancement through serial evaluations or biomarker integration.[22] The present study has a few limitations. The first limitation is its, single-institution study design which however restricts the generalizability of the results. Furthermore, single time-point scoring system measurements limit the predictive utility of these tools in the study. Sepsis is a dynamic process and can change rapidly, and static scores might not accurately predict the evolution of disease or the response to treatment. In conclusion, although the present work provides important data on complestatin in relation to prediction of risk of suffering sepsis, its limitations outline two crucial issues for further investigation. There is a need for large, multicentre studies with comprehensive data collection and sophisticated analytic methods to create more precise, individualized and clinically-relevant prognostic instruments.

CONCLUSION

This study provides a thorough comparison of the performance of popular clinical scoring schemas for predicting septic mortality, with the APACHE II score exhibiting the best omnibus performance. The APACHE II model combines numerous physiological parameters, age and underlying comorbidity and gives a comprehensive overview of patient illness severity and prognostic profile. The capacity to incorporate these multifactorial elements allows a more subtle risk stratification, and could be particularly useful in intensive care at the time to allocate resources or make decisions.

Yet despite its strength, APACHE II is labour-intensive and resource-heavy, potentially limiting its general application in busy or resource-scarce settings. In this sense, the study reinforces the value of MEWS when combined with serum lactate levels, as a simple and feasible bedside instrument. MEWS, which is calculated by using basic vital signs, including breathing rate, heart rate, blood pressure, body temperature and level of consciousness, is easy to calculate and few equipments are necessary. Lactate measurement—commonly used as an indicator of tissue hypoxia and systemic stress—added to MEWS, "MEWS+Lactate" improves the early warning for deterioration, and is a more practical alternative to be used by front-line care personnel primarily in emergency departments and general wards.

In addition, the SOFA score continues to be a foundation for evaluating organ dysfunction, especially as related to sepsis. Its incorporation of respiratory, cardiovascular, hepatic, coagulation, renal and neurological scores allow multi-system evaluation mirroring the morbidity and mortality. The results of this study stress the importance of SOFA for tracking the deterioration of organ failure and to guide appropriate therapeutic measures, also noting, however, that the value of SOFA as a predictive tool will vary depending on the source of infection. For example, septic shock attributable to respiratory infections may present in SOFA trends differently compared to intra-abdominal or urinary sources and warrants source-specific roadmaps that reflect these differences.

The documented differences of SOFA and lactate behaviour according to infection source again stress the necessity of a personalized sepsis management. As heterogeneity of the disease becomes evident, a one-size-fits-all approach may prove to be inadequate. Identification of these differences will allow clinicians to predict and prepare for complications and modify treatment accordingly.

In conclusion, the study calls for a rational approach in the clinic, which may be that the advantages of full and simple scoring should be combined. APACHE II gives detailed prognostic information assuming high resource use, and MEWS+Lactate provides a rapid triage system for early intervention. Meanwhile, SOFA continues to be important in the prospective documentation of organ dysfunction, especially in intensive care unit settings. The collective use of these tools facilitates patient management strategies that are adaptable and context-specific and enhances patient outcomes in a variety of clinical scenarios. This innovative, layered approach is consistent with prevailing themes of precision medicine and highlights the need for flexibility and condition awareness in the management of critically ill patients.

Table: Summary of Results Compared with Other Studies

Study (Year)	Sample Size	Mortality Rate (%)	APACHE II (AUC)	SOFA (AUC)	MEWS + Lactate (AUC)	Key Findings
Current Study (2025)	201	21.9	0.920	0.873	0.883	APACHE II best predictor; MEWS + Lactate practical; SOFA effective for organ dysfunction.
Vincent et al. (1996) [23]	1,449	34.0	0.85	0.70	-	SOFA validated for organ failure; APACHE II superior overall.
Mikkelsen et al. (2009) [13]	1,178	38.0	0.88	0.82	-	Lactate >4 mmol/L linked to mortality; SOFA less predictive than APACHE II.
Raith et al. (2017) [24]	1,84,875	22.0	0.90	0.74	-	SOFA outperformed by APACHE II in ICU mortality prediction.
Tekin et al. (2024) [20]	320	28.0	0.87	0.80	-	APACHE II and SOFA effective; elderly sepsis cohort showed higher mortality.
Kądziołka et al. (2019) [21]	1,200	25.0	0.89	0.71	-	APACHE II validated; SOFA less accurate at admission.

Note: AUC values are approximate and vary by study design and population. "-" indicates data not reported.

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