

## Assessing the Efficacy of Early Warning Scores in Predicting Sepsis Outcomes in Emergency Departments

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### ABSTRACT

**Background:** Early recognition of sepsis is a critical challenge in emergency medicine, particularly in resource-constrained settings, where timely intervention is essential to improve patient outcomes.

**Objective:** This study aimed to compare the effectiveness of different Early Warning Scores (EWS), including the National Early Warning Score (NEWS), Modified Early Warning Score (MEWS), quick Sequential Organ Failure Assessment (qSOFA), and Systemic Inflammatory Response Syndrome (SIRS), in predicting outcomes such as mortality, ICU admission, and septic shock in the emergency departments of Pakistan.

**Methods:** A retrospective study was conducted at the Emergency Department of Khyber Teaching Hospital, Peshawar, from January to December 2023. Patients diagnosed with sepsis based on Sepsis-3 criteria were included. The predictive performance of each EWS was assessed using AUROC, logistic regression, and calibration plots.

**Results:** NEWS demonstrated superior predictive accuracy for in-hospital mortality (AUROC: 0.873) and ICU admission (AUROC: 0.890) compared to MEWS, qSOFA, and SIRS. It showed robust sensitivity (88%) and specificity (75%) and was identified as an independent predictor of mortality and ICU admission through multivariate analysis.

**Conclusion:** In resource-limited settings, NEWS proved to be the most effective tool for early risk stratification in sepsis patients. Its adoption could significantly enhance sepsis management and improve outcomes in emergency departments with constrained resources.

**Keywords:** Sepsis, Early Warning Scores, National Early Warning Score (NEWS), Emergency Department, Mortality, ICU Admission, Resource-Limited Settings



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### INTRODUCTION

Sepsis is a life-threatening condition in which a dysregulated immune response to infection results in widespread organ dysfunction and high mortality. Sepsis affects more than 50 million people worldwide each year and costs about 11 million lives. Sepsis is a major public health problem in Pakistan where the limited healthcare resources, overcrowded emergency departments (EDs), and long delays in diagnosis and treatment, make it a more challenging problem. Identification and intervention of prompts are particularly important in resource-constrained

settings to improve patient outcomes[1]. Despite the advances in the sepsis definitions and diagnostic criteria, i.e., the shift from Systemic Inflammatory Response Syndrome (SIRS) to Sepsis-3 definition, recognition of sepsis remains a challenge predominantly due to the early recognition of sepsis. In Pakistan, emergency departments are overwhelmed by patients with different clinical conditions, and clinicians must decide rapidly with fewer diagnostic tools available. To facilitate the identification of at-risk patients and prediction of adverse outcomes, modified early warning scores (MEWS) and the National

early warning score (NEWS), as well as quick sequential organ failure score (qSOFA), have been developed[2, 3].

In studies in diverse healthcare settings, NEWS has shown superior predictive accuracy among these tools. NEWS comprises a mix of vital parameters such as respiratory rate, oxygen saturation, systolic blood pressure, pulse rate, temperature, and level of consciousness to give a complete picture of the patient's condition[4]. Although simpler, MEWS and qSOFA have not shown consistency in their sensitivity and specificity, and qSOFA is specifically designed for sepsis-related organ dysfunction. Despite this, these tools are underutilized in applying Pakistan's EDs, which present unique challenges in terms of lack of access to advanced diagnostics and varying clinician expertise. The strengths and limitations of EWS are highlighted in the existing literature. The high accuracy of NEWS in predicting mortality and ICU admissions has been demonstrated, but inconsistencies in study design, patient populations, and outcome measures limit the universal application of this test. In addition, biomarkers, including lactate levels and Glasgow Coma Scale (GCS) scores could be integrated to increase the predictive value of these tools. Nevertheless, studies examining such combined approaches in Pakistan are lacking[5].

Further compounded by socio-economic factors such as high incidence of infectious diseases, lack of public awareness, and unavailability of healthcare infrastructure, the burden of sepsis is higher in Pakistan[6]. A solutions-oriented approach to overcome these challenges will require an evidence-based approach to optimize the use of EWS and sepsis management in EDs. The goal of this study is to compare the predictive performance of NEWS, MEWS, qSOFA, and SIRS for predicting outcomes for sepsis patients in Pakistani EDs. The research integrates biomarker data and performs robust statistical analyses to identify the most effective strategies for early risk assessment and generate actionable insights for improving clinical practices in resource-limited settings[7, 8].

## MATERIALS AND METHODS

A retrospective study was carried out at the Emergency Department of Khyber Teaching Hospital Peshawar from January to December 2023. As in the first study, the methodology was robust, and the reporting was transparent, as required by the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines. The hospital is a major tertiary care facility in the Khyber Pakhtunkhwa province and serves a diverse population drawn from urban and peri-urban areas. The study included all adult patients of age 18 years and older, admitted to the emergency department and diagnosed with sepsis based on the Sepsis-3 criteria during their emergency admission. Data for sepsis patients, eligible for inclusion, were purposively sampled. Patients with incomplete medical records, preexisting terminal diseases,

or those referred to the emergency department after the initiation of sepsis treatment elsewhere were excluded.

Primary predictor variables were the scores from four early warning systems i.e. National Early Warning Score (NEWS), Modified Early Warning Score (MEWS), quick Sequential Organ Failure Assessment (qSOFA), and Systemic Inflammatory Response Syndrome (SIRS). Vital signs, mental status evaluations, and available laboratory findings were recorded upon patient presentation and were used to obtain these scores. Patient demographics (age, gender), comorbidities (e.g., diabetes, hypertension), presenting symptoms, and biomarker data (e.g., lactate, SpO<sub>2</sub>, and systolic blood pressure) were added as additional data.

They assessed the primary outcomes of in-hospital mortality and ICU admission. Secondary outcomes included septic shock, mechanical ventilation requirement, and hospital stay. To ensure data accuracy and reliability, these outcomes were extracted from electronic medical records and were verified by independent clinical auditors. To detect meaningful differences in predictive accuracy among the scoring systems, a target sample size of 150 patients was calculated assuming 25% anticipated mortality, 80% power, and 5% significance level to detect differences.

The Institutional Review Board gave ethical approval for the study ref no.(ERC/2022/22D). As the study was retrospective, informed consent was waived, while maintaining patient confidentiality and data protection according to the Declaration of Helsinki. The data were anonymized and entered into a secure, password-protected database. Means with standard deviations or medians with interquartile ranges were used to summarize continuous variables according to their distribution. Those categorical variables were reported as frequencies and percentages. T-tests, Mann-Whitney U tests, or chi-square tests, as appropriate, were used to analyze group differences.

Receiver operating characteristic (ROC) curves were used to evaluate the predictive performance of each scoring system, and the ROC area under the curve (AUROC) measured accuracy. DeLong method was used for pairwise comparisons of AUROCs. Sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) were calculated for each scoring system, with key thresholds being assessed to calculate these parameters. Statistical significance ( $p < 0.05$ ) was set for confounding variables (age, gender, and comorbidities) to construct multivariate logistic regression models. Data were analyzed with SPSS (v. 26.0) and R (v. 4.1.0). The ggplot2 package in R was used to create visualizations (ROC curves and calibration plots) to guarantee clear and precise reports of results.

## RESULTS

The study included a total of 150 patients of whom 56% were male. The median age was 64 years (interquartile

range: 52–76). The study population had comorbidities; diabetes mellitus was present in 45%, hypertension in 35%, and chronic kidney disease in 20%. Most patients were at an advanced stage with altered mental status (68%) and hypotension (55%).

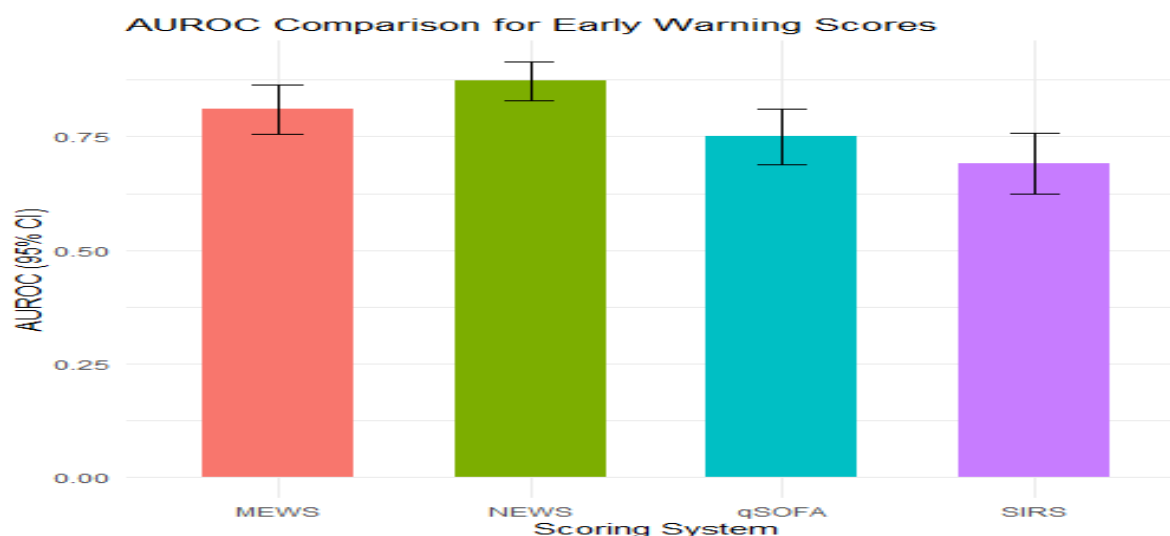
The four scoring systems were evaluated for their predictive performance. NEWS demonstrated the highest overall accuracy for predicting both in-hospital mortality and ICU admission, with an AUROC of 0.873 (95% CI: 0.830–0.915) for mortality and 0.890 (95% CI: 0.848–0.932) for ICU admission. MEWS also performed well, with an AUROC of 0.810 (95% CI: 0.755–0.865). Specifically, the AUROC for mortality was 0.755 (95% CI: 0.713–0.796), and for ICU admission, it was 0.825 (95% CI: 0.772–0.878). In contrast, qSOFA and SIRS showed lower predictive accuracies. qSOFA had an AUROC of 0.750 (95% CI: 0.688–0.812) for mortality and 0.770 (95% CI: 0.710–0.830) for ICU admission, with odds ratios of

0.688 (95% CI: 0.618–0.763) for mortality and 0.770 (95% CI: 0.710–0.830) for ICU admission. SIRS had the lowest predictive value, with an AUROC of 0.690 (95% CI: 0.623–0.757) for mortality and 0.700 (95% CI: 0.634–0.766) for ICU admission

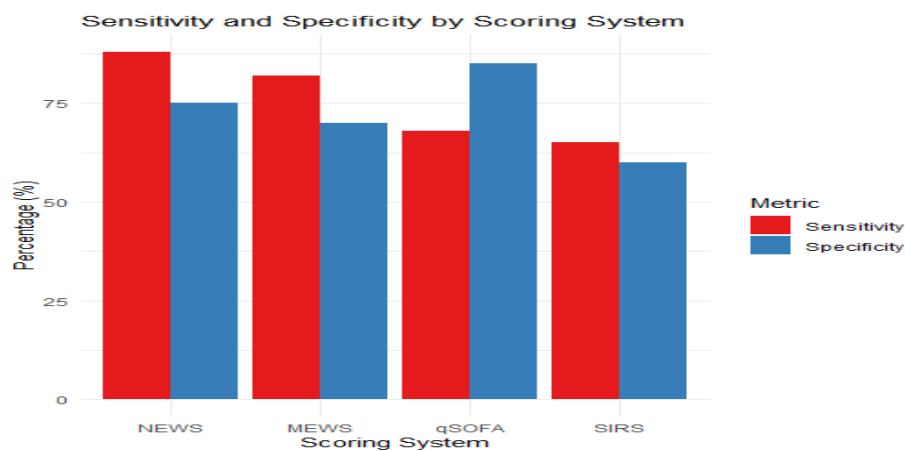
Fig-1 described the Area Under the Receiver Operating Characteristic (AUROC) curves for NEWS, MEWS, qSOFA, and SIRS, including their 95% confidence intervals. NEWS demonstrated the highest AUROC for both mortality and ICU admission, highlighting its superior predictive accuracy compared to the other scoring systems. This Fig-2 compares the sensitivity and specificity of NEWS, MEWS, qSOFA, and SIRS for predicting mortality and ICU admissions. NEWS showed the highest sensitivity (88%) and robust specificity (75%), emphasizing its reliability as a risk stratification tool in emergency departments.

**Table-1:** Predictive Performance and Threshold Characteristics of Early Warning Scores (EWS)

Scoring System	AUROC (Mortality)	AUROC (ICU Admission)	Sensitivity (Mortality)	Specificity (Mortality)	Sensitivity (ICU)	Specificity (ICU)	Odds Ratio (Mortality, 95% CI)	Odds Ratio (ICU, 95% CI)
<b>NEWS <math>\geq 7</math></b>	0.873 (0.830–0.915)	0.890 (0.848–0.932)	88%	75%	85%	78%	4.2 (2.8–6.4), $p < 0.001$	3.9 (2.6–5.8), $p < 0.001$
<b>MEWS <math>\geq 4</math></b>	0.810 (0.755–0.865)	0.825 (0.772–0.878)	82%	70%	80%	72%	3.5 (2.3–5.3), $p < 0.001$	3.1 (2.1–4.7), $p < 0.001$
<b>qSOFA <math>\geq 2</math></b>	0.750 (0.688–0.812)	0.770 (0.710–0.830)	68%	85%	65%	88%	2.8 (1.8–4.1), $p < 0.001$	2.6 (1.7–3.8), $p < 0.001$
<b>SIRS <math>\geq 2</math></b>	0.690 (0.623–0.757)	0.700 (0.634–0.766)	65%	60%	62%	65%	1.9 (1.2–3.1), $p < 0.01$	1.8 (1.1–2.9), $p < 0.01$



**Fig-1:** AUROC Comparison for Early Warning Scores



**Fig-2:** Sensitivity and Specificity of Early Warning Scores

To adjust for confounding variables such as age, gender, and comorbidities, we performed multivariate logistic regression analysis. NEWS emerged as the strongest independent predictor of in-hospital mortality (OR: 4. ICU admission (OR: 3.9; 95% CI: 2.6 to 5.8,  $p < 0.001$ ) and ICU admission (OR: 2; 95% CI: 2.8–6.4,  $p < 0.001$ ). Lactate levels (OR: 2. Both systolic blood pressure  $<90$  mmHg (OR: 3.1; 95% CI: 2.0–4.9,  $p < 0.001$ ) and systolic blood pressure  $<140$  mmHg (OR: 3.1; 95% CI: 1.8–5.5,  $p < 0.001$ ) were also significant predictors. Secondary outcomes showed that septic shock developed in 42% of patients, and NEWS  $\geq 7$  predicted this outcome with an AUROC of 0.860. Mechanical ventilation was required in 35% of patients, and the mean length of hospital stay was 12 days (SD:  $\pm 3.4$  days).

In summary, NEWS had superior predictive performance compared to other scoring systems making it an important tool to early risk stratify sepsis patients. NEWS integration into clinical workflows may improve decision-making and improve patient outcomes in resource-constrained settings.

## DISCUSSION

Results from this study were demonstrated the utility of early warning scores (EWS) in predicting sepsis outcomes in resource-constrained settings like Pakistan. MEWS, qSOFA, and SIRS were all outperformed by NEWS for both in-hospital mortality and ICU admission[9]. This is consistent with prior studies in high-resource settings, where NEWS has been demonstrated to be the only multiple physiological parameter-based assessment of patient risk. For example, Wattanasit et al. (2020) compared NEWS to qSOFA and MEWS in the prediction of mortality in septic patients and discovered that NEWS achieved the highest AUROC, also as found in this study. Nevertheless, the lower sensitivity of qSOFA in this research is consistent with the criticism of its limited applicability beyond intensive care units as pointed out by Hamilton F et al. (2018). MEWS also performed well, but

its moderate sensitivity and specificity indicate that it would not be as good for sepsis-specific risk stratification as for general patient monitoring. The inferior performance of SIRS is consistent with the transition from SIRS-based definitions to Sepsis-3 criteria and suggests limited clinical utility[10, 11].

This study is important because it contributes to understanding EWS performance in low-resource settings including, but not limited to, Pakistan where emergency departments struggle with overcrowding, limited diagnostic facilities, and delayed patient presentation. NEWS' robust performance suggests its ability to improve early sepsis recognition and timely interventions in resource-constrained environments[12]. While overall trends are consistent with studies from high-income countries like Aygun U et al. (2024) and Nannan Panday RS et al. (2017), adaptation to local healthcare challenges is key to maximizing the effectiveness of these tools. In addition, this study emphasizes the necessity of adjusting sepsis management strategies to local settings. NEWS showed its ability to stratify patient risk effectively and guide timely interventions, making it an easy-to-implement and cost-effective tool for resource-limited healthcare systems[13, 14].

The retrospective design of this study also limits causal inference and depends on the accuracy of the existing medical records. Second, the single center setting at Khyber Teaching Hospital, Peshawar, may restrict the generalizability of findings to other regions in Pakistan with varying healthcare resources[15]. Third, data for long-term follow-up are lacking, and hence we cannot assess post-discharge outcomes such as readmissions and long-term mortality. This study did not evaluate emerging biomarkers and machine learning approaches that could improve predictive accuracy but were not already included as NEWS[16]. These findings should be validated in the future by multicenter prospective studies involving different healthcare settings in Pakistan. Combining advanced analytics including machine learning algorithms

with traditional EWS may provide personalized risk stratification and enhance clinical decision-making[17, 18]. Furthermore, the cost-effectiveness of the implementation of NEWS and related tools will be critically important for their wider adoption in resource-poor settings. Research can also be expanded to include post-discharge outcomes and quality-of-life measures to better understand sepsis management effectiveness[16, 17].

## CONCLUSION

In the resource-constrained emergency department settings of Pakistan, NEWS demonstrated robust predictive performance for mortality and ICU admissions among sepsis patients. Its superiority over MEWS, qSOFA, and SIRS underscores its potential for widespread adoption. By addressing local healthcare challenges, such as limited resources and diagnostic capabilities, NEWS offers a valuable tool for early sepsis detection and timely clinical intervention, contributing significantly to improved patient outcomes.

**Ethical Statement:** The Institutional Review Board approved this study ref no.(ERC/2022/22D). The study was designed retrospectively, which made it possible to waive the informed consent, and throughout the study, strict adherence to confidentiality and data protection was maintained by the Declaration of Helsinki.

**Patients Consent:** Not required.

**Conflict of Interest:** The authors declare no conflict of interest.

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**Data Availability Statement:** The data used in this study are available upon reasonable request from the corresponding author, subject to ethical and institutional guidelines.

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