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Scoring Systems in Sepsis: A Comprehensive Review

[1]Judat Tasawoor, [2]Mariya Manzoor, [3]Abir Aijaz, [4]Manzoor Wani, [5]Shabir A Haider

Corresponding Author: Judat Tasawoor, Medical Officer Subdistrict Hospital Sopore, J&K, India

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Abstract

Sepsis remains a major cause of morbidity and mortality worldwide. Early identification of organ dysfunction using robust scoring systems profoundly influences patient outcomes. This review explores conventional systems such as SOFA, qSOFA, SIRS, NEWS, APACHE, SAPS and emerging models including POSMI, biomarker-augmented tools, and machine-learning (ML) algorithms. Strengths, limitations, validation status, and clinical utility are assessed, with recommendations aligned to current Surviving Sepsis Campaign and Sepsis-3 guidelines.

Keywords: Lab Dependency, Heart Rate, Procalcitonin, Presepsin

Introduction

Sepsis is defined by Sepsis-3 as "life-threatening organ dysfunction caused by a dysregulated host response to infection", operationalized by an increase of ≥2 points in the SOFA score[1]. Globally, sepsis affects nearly 50 million people annually, with an estimated 11 million deaths approximately 20% of all global fatalities [2]. Efficient triage and prognosis rely heavily on reliable scoring systems that can rapidly identify at-risk patients and allocate critical care resources appropriately.

1. Bedside Early Warning Scores

A. SIRS

Derived from consensus in 1991, Systemic Inflammatory Response Syndrome (SIRS) encompasses at least two of the following: abnormal temperature, heart rate, respiratory rate, or white blood cell count [3]. SIRS intended to cast a wide net for sepsis identification, offering high sensitivity but poor specificity. It was de-emphasized in Sepsis-3 due to excessive false positives and weak correlation with mortality[4].

B. qSOFA

Introduced in 2016, the Quick SOFA (qSOFA) score comprises three clinical criteria: respiratory rate ≥ 22/min, systolic BP ≤ 100 mmHg, and GCS < 15, with a score ≥2 indicating likely sepsis with high risk of death or prolonged ICU stay [1,5]. Extensive validation has shown qSOFA to have moderate specificity (82–85%) but low sensitivity (~55%), making it better suited as a rule-in tool rather than screening [6].

C. NEWS/NEWS2 & MEWS

The National Early Warning Score (NEWS) and its updated version NEWS2, alongside Modified Early Warning Score(MEWS), evaluate six vital signs daily. They are widely used on wards and in EDs. The NEWS2 algorithm outperforms qSOFA and SIRS in sepsis detection, often scoring AUROC 0.75–0.85 for predicting deterioration [7,8]. MEWS is simpler but generally less predictive than NEWS.

2. ICU-Focused Physiologic Scores

A. SOFA

The Sequential (Organ) Failure Assessment (SOFA) score, introduced in 1996, grades dysfunction across six organ systems on a 0–4 scale, summing to a max of 24 [9]. A rising SOFA score predicts mortality with high accuracy (AUROC ~0.86) and is fundamental to Sepsis-3 definitions [1]. Limitations include reliance on lab results and limited utility in early triage.

B. APACHE II/IV

Acute Physiology and Chronic Health Evaluation (APACHE) models assess acute physiology, age, and comorbidities. APACHE II and IV predict ICU mortality accurately (AUROC ~0.87) but are difficult to compute at the bedside due to complex scoring, and are mostly used for research and outcome benchmarking [10,11].

C. SAPS II

The Simplified Acute Physiology Score II estimates ICU mortality using 17 variables. It possesses discrimination (AUROC ~0.83) comparable to APACHE but is still resource-intensive and less used at the bedside [10].

3. Novel & Combined Scoring Systems

A. POSMI

The Predictive Score for ICU Mortality in Sepsis (POSMI) was developed using a large multicenter ICU cohort of sepsis patients [12]. With just seven variables (age, albumin, ventilation status, bilirubin, BUN, presence of cancer, and SpO_2), it matches or exceeds APACHE IV and SOFA in prognostic accuracy (AUROC: 0.80–0.83) [12].

B. MEDS Score

The Mortality in Emergency Department Sepsis (MEDS) includes age, terminal illness, infection source, nursing home residence, altered mental status, and more [13]. Though validated (AUROC ~0.76–0.85), its complexity and focus on emergency department make it less widely used.

C. Biomarker-Augmented Scoring

Laboratory markers like lactate, procalcitonin (PCT), and presepsin offer prognostic value. Lactate >2 mmol/L predicts higher mortality independently, contributing to the popular "qtSOFA + lactate" approach [14]. PCT and presepsin further improve prognostic accuracy when combined with clinical scores in AUROC analyses (e.g., PCT + SOFA achieves AUROC ~0.89) [15,16].

4. Machine-Learning & AI-Enhanced Predictions

A. DBN-Based Models

Dynamic Bayesian Network models using time-series vitals and labs can predict septic shock with high accuracy (AUROC ~0.91) and up to 12 hours earlier than conventional tools [17].

B. Deep Learning Ensembles

Ensembles like Random Forests using ≥30 features (vitals, labs, demographics) have reached AUROC ~0.94 in ICU mortality prediction [18]. Preliminary results show promise but require independent external validation.

C. SXI++ LNM

The emerging SXI++ LNM neural-network model claims near-perfect prediction (AUROC 0.99). However, it awaits peer-reviewed publication and clinical validation[19].

5. **Comparative Performance**

- **Early warning utility**: NEWS2 > qSOFA > SIRS in AUROC; NEWS2 is the top choice for ward-based early detection [7,8].
- **ICU mortality prediction**: APACHE II/IV and SOFA (AUROC 0.82–0.86) outperform MEWS, qSOFA [10,11].
- **POSMI vs others**: In sepsis-specific ICU cohorts, POSMI equals or outperforms APACHE IV and SOFA with greater ease of use [12].

- **Biomarker combination**: Inclusion of PCT and lactate can raise AUROC values by 0.05–0.10 beyond clinical scores alone [15,16].
- **Machine learning algorithms**: Show AUROCs 0.90–0.95, easily outperforming traditional tools—but suffer from limited transparency and external validation [17,18].

6. Guidelines & Real-World Application

A. Sepsis-3 (2016)

Recommends diagnosing sepsis based on SOFA increase ≥2 and considering qSOFA's bedside utility outside the ICU, but labels it inadequate for sole use [1,4].

B. Surviving Sepsis Campaign

The 2021 update advises against using qSOFA alone for ruling out sepsis, recommending its combination with SIRS, NEWS, or MEWS. It continues to endorse SOFA and APACHE for ICU prognostication [20].

7. Strengths, Limitations & Clinical Context

SIRS and qSOFA: quick and easy but risk under- or over-identification.

NEWS: high sensitivity useful for triggering early care. **SOFA, APACHE, SAPS**: highly predictive but resource-intensive—they excel in ICU audit/research. **POSMI**: strikes practical balance between accuracy and usability in sepsis patients.

Biomarker-enhanced scores: improve accuracy but at the cost of time, lab dependency, and cost. **ML-based tools**: show extraordinary predictive power, but lack interpretability and robust external validation.

8. Future Directions

- **Prospective validation of POSMI** in diverse ICUs.
- **Hybrid clinical-biologic scores**: e.g., SOFA + PCT or presepsin.
- **Explainable AI models** for transparent decision support.
- **Integration into EHRs** to automate scoring (e.g., real-time SOFA or predictive ML alerts).
- **Global applicability**: tools validated in low-resource regions are still lacking.

Conclusions

Scoring systems in sepsis facilitate timely detection, triage, and risk stratification. Sepsis-3 recognizes SOFA as the standard for diagnosing organ dysfunction; NEWS2 excels in early detection on wards; qSOFA offers rapid triage but lacks sensitivity alone. ICU mortality prediction remains in the realm of APACHE and adjunctive tools like POSMI. Developing biomarker-augmented and AI-driven scores offers future promise—and may soon guide real-time clinical decision-making across diverse care environments.

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