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COMBINED PREDICTIVE VALUE OF SOFA SCORE AND ADMISSION LACTATE FOR IN-HOSPITAL MORTALITY IN SEPTIC PATIENTS

Original Research (ID: 1708)

Dr Momina Mazhar Ali Khilji[1]*, Dr Ambrina Qavi[2], Dr Shariq Nawab[3], Dr Samiyya Rasool Abbasi[1], Dr Zeeshan Ali[4]
[1]Post Graduate Trainee (MICU Ward 23), Jinnah Postgraduate Medical Centre
[2]Family Medicine Resident, Ziauddin University Hospital
[3]Family Medicine Resident, Ziauddin University Hospital
[4]Professor Of Medicine (MICU Ward 23), Jinnah Sindh Medical University/ Jinnah Postgraduate Medical Center
Corresponding Author: Dr Momina Mazhar Ali Khilji, mominajsmu@gmail.com, Post Graduate Trainee (MICU Ward 23), Jinnah Postgraduate Medical Centre
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ABSTRACT

Background: Sepsis remains a major cause of preventable hospital death, and early recognition of patients at greatest risk is central to timely resuscitation and critical care planning. The Sequential Organ Failure Assessment (SOFA) score measures the extent of acute organ dysfunction, whereas serum lactate reflects metabolic stress and impaired tissue perfusion. Although both are established prognostic indicators, the additional value obtained by combining them at admission has not been fully define d, particularly in resource-constrained hospitals.

Objective: To assess the individual and combined predictive value of admission SOFA score and serum lactate for in-hospital mortality in adults with sepsis.

Methods: This hospital-based observational analytical study included 210 adults fulfilling Sepsis-3 criteria who were managed in the emergency department, medical ward, or medical intensive care unit of Jinnah Postgraduate Medical Centre. Clinical and laboratory data were extracted from patient records using a structured proforma. The SOFA score and first lactate concentration obtained within 24 hours were analysed using multivariable logistic regression and receiver operating characteristic curves. Optimal thresholds were derived through the Youden index, and AUCs were compared using the DeLong test.

Results: In-hospital mortality was 27.6%. Non-survivors had higher median SOFA scores than survivors, 8.5 versus 2.0, and higher lactate concentrations, 4.6 versus 2.4 mmol/L (both $p < 0.001$). Lactate independently predicted mortality (adjusted OR 1.54, 95% CI 1.13–2.08; $p = 0.006$), as did SOFA score (adjusted OR 1.28, 95% CI 1.13–1.45; $p < 0.001$). The AUC was 0.802 for lactate, 0.805 for SOFA, and 0.832 for the combined model. The combined model yielded 74.1% sensitivity, 81.6% specificity, 60.6% positive predictive value, and 89.2% negative predictive value. Its AUC was numerically higher t han either marker alone, although the differences were not statistically significant.

Conclusion: Admission SOFA score and serum lactate independently predicted in-hospital mortality, while their combined assessment provided the highest discrimination for practical early risk stratification.

Keywords: Hospital Mortality; Lactic Acid; Logistic Models; Organ Dysfunction Scores; Prognosis; Sepsis; Shock, Septic.

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INTRODUCTION

Sepsis remains one of the most serious and time-sensitive medical conditions encountered in emergency departments, medical wards and intensive care units. It develops when the host response to infection becomes dysregulated, leading to acute organ dysfunction and potentially irreversible physiological deterioration. According to the Third International Consensus Definitions for Sepsis and Septic Shock, sepsis is defined as life-threatening organ dysfunction caused by an abnormal host response to infection, with organ dysfunction operationally identified by an acute increase of at least two points in the Sequential Organ Failure Assessment (SOFA) score (1-3). Despite advances in antimicrobial therapy, haemodynamic support and critical care, sepsis continues to cause substantial morbidity, prolonged hospitalization and death. Global estimates suggest that approximately 49 million cases of sepsis occur annually, contributing to nearly 11 million deaths and almost one-fifth of all deaths worldwide (3-5). Its burden is particularly severe in low- and middle-income countries, where delayed presentation, limited availability of intensive care beds, inadequate diagnostic facilities and restricted access to trained critical care personnel may adversely affect outcomes. The clinical course of sepsis is highly variable. Some patients respond promptly to initial treatment, whereas others deteriorate rapidly and develop septic shock, multiple-organ failure or death. This unpredictable progression makes early risk assessment an essential component of sepsis management. Identifying patients who are likely to experience poor outcomes at the time of hospital admission may allow clinicians to initiate more intensive resuscitation, administer appropriate antimicrobial therapy without delay, optimize haemodynamic support and arrange early transfer to a higher level of care. Reliable prognostic assessment may also assist in prioritizing limited critical care resources, particularly in hospitals where the demand for intensive monitoring exceeds the available capacity. However, the heterogeneity of sepsis means that no single clinical sign or routine laboratory measurement can fully represent the complex interaction between infection, circulatory impairment, metabolic disturbance and organ dysfunction (5-7).

The SOFA score is one of the most widely used tools for assessing the severity of organ dysfunction in patients with sepsis. It evaluates six major organ systems: respiratory, cardiovascular, hepatic, coagulation, neurological and renal. Each component is scored according to the degree of physiological impairment, producing a composite measure of overall organ dysfunction. Higher SOFA scores have consistently been associated with greater illness severity, increased need for intensive care, longer hospital stay and higher mortality. The score has therefore become central to the clinical definition of sepsis and is commonly used in both clinical practice and research (7-9). Its strength lies in its systematic assessment of established organ dysfunction across several physiological systems. Nevertheless, the SOFA score may not fully capture the early metabolic and microcirculatory abnormalities that can occur before clinically apparent or advanced organ failure develops. Consequently, patients with similar SOFA scores may still have different levels of tissue hypoperfusion and different risks of deterioration. Serum lactate provides a complementary assessment of physiological stress in sepsis. Elevated lactate levels may result from impaired tissue perfusion, cellular hypoxia, accelerated glycolysis, mitochondrial dysfunction, adrenergic stimulation or reduced hepatic clearance. Although lactate was traditionally regarded mainly as a marker of anaerobic metabolism, its elevation in sepsis is now understood to reflect several overlapping metabolic and circulatory processes. Hyperlactataemia has been associated with haemodynamic instability, vasopressor requirement, septic shock, multiple-organ dysfunction and increased mortality. Importantly, lactate may be raised even when systemic blood pressure appears normal, thereby helping to identify patients with occult tissue hypoperfusion who might otherwise be considered clinically stable. For this reason, international sepsis guidelines recommend early lactate measurement in patients with suspected sepsis, while persistently elevated or increasing levels after initial resuscitation are regarded as indicators of an unfavourable clinical course (10-12).

Although both the admission SOFA score and serum lactate concentration have demonstrated prognostic value, they represent different aspects of the pathophysiological response to sepsis. The SOFA score primarily reflects the extent of measurable organ dysfunction, whereas lactate provides information regarding metabolic stress, impaired perfusion and altered cellular function. Their combined use may therefore provide a more complete assessment of disease severity than either parameter considered alone. A patient may, for example, have substantial metabolic disturbance before severe organ dysfunction is reflected in the SOFA score, while another patient may have established organ failure without a markedly elevated lactate concentration. Combining the two markers could potentially identify these differing high-risk patterns and improve the discrimination of patients who are likely to die during hospitalization. Several prognostic models have been developed for septic patients, but many require numerous clinical variables, repeated measurements or investigations that may not be readily available in resource-constrained settings. Complex scoring systems can also be difficult to apply during the early phase of admission, when rapid decisions are required. In contrast, the SOFA score and serum lactate are routinely obtained in many hospitals and can be interpreted soon after presentation. A model based on these readily accessible indicators may therefore provide a practical method of early risk stratification without requiring expensive or specialized testing. Previous studies have shown that combining clinical scores with biochemical markers may improve mortality prediction; however, the added prognostic value of combining the admission SOFA score with the initial serum lactate level has not been adequately established across different hospital populations, particularly in healthcare systems with limited critical care resources (12,13).

Determining whether the combined assessment offers meaningful improvement is clinically important. More accurate early prediction may help clinicians recognize patients requiring aggressive resuscitation, closer haemodynamic surveillance, early vasopressor support or prompt intensive care admission. It may also support communication with patients' families and improve the allocation of limited beds, equipment and trained staff. At the same time, a simple prognostic approach must be sufficiently reliable to avoid unnecessary

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escalation of care in patients at comparatively lower risk. The clinical value of combining SOFA and lactate should therefore be assessed not only through their independent associations with mortality but also by determining whether the combined model improves overall discrimination. The present study was undertaken to evaluate the predictive value of the admission SOFA score and serum lactate level for in-hospital mortality among adult patients with sepsis. It specifically aimed to compare the prognostic performance of SOFA score alone, admission lactate alone and a combined model incorporating both variables using receiver operating characteristic curve analysis and multivariable logistic regression. It was hypothesized that the combined assessment of organ dysfunction and metabolic derangement would predict in-hospital mortality more accurately than either marker used independently, thereby providing a simple, accessible and clinically relevant approach to early risk stratification in septic patients.

METHODOLOGY

A hospital-based observational analytical study was conducted in the Emergency Department, Department of Medicine and Medical Intensive Care Unit of Jinnah Postgraduate Medical Centre over a period of three months. The study evaluated the individual and combined predictive performance of the Sequential Organ Failure Assessment (SOFA) score and admission serum lactate concentration for in-hospital mortality among adults with sepsis. Participants were enrolled through non-probability consecutive sampling after approval had been obtained from the Institutional Review Board of the institution. The study was conducted in accordance with the ethical principles of the Declaration of Helsinki. Written informed consent was obtained from each patient or, where the patient lacked decision-making capacity because of critical illness, from a legally authorised representative. Confidentiality was maintained by recording study data on coded proformas without using personally identifiable information. Adult patients aged 18 years or older who presented with a suspected or microbiologically documented infection and fulfilled the Sepsis-3 diagnostic criteria were considered eligible. Sepsis was defined as life-threatening organ dysfunction caused by a dysregulated host response to infection, operationalised as an acute increase of at least two points in the SOFA score. Patients admitted through the emergency department to the medical ward or medical intensive care unit were included when serum lactate had been measured within the first 24 hours of admission and the final hospital outcome was available. Patients were excluded if they had experienced cardiac arrest before hospital admission, were pregnant, declined consent, had been discharged, transferred or had died before completion of the initial 24-hour assessment, or had incomplete information required to calculate the SOFA score or determine serum lactate and final hospital outcome. After application of the eligibility criteria, 210 patients were included in the final analysis.

Data were collected manually from handwritten hospital files, patient case records, laboratory reports and monitoring charts using a structured proforma developed for the study. The proforma was used consistently for all participants to improve uniformity and reduce variation in data extraction. Demographic characteristics included age, sex and body weight, while relevant comorbidities included diabetes mellitus, hypertension, chronic kidney disease and other documented chronic conditions. Clinical information recorded at presentation included the suspected source of infection, vital signs, Glasgow Coma Scale score, location of admission, presence of septic shock and requirement for oxygen therapy. The use of invasive mechanical ventilation, vasopressor support and renal replacement therapy was also documented. Duration of intensive care unit and total hospital stay were recorded, together with the final in-hospital outcome, which was categorised as survival to discharge or in-hospital death. Laboratory variables included serum lactate, haemoglobin concentration, total white blood cell count, platelet count, serum creatinine, total bilirubin and the ratio of arterial oxygen partial pressure to fractional inspired oxygen concentration. Admission lactate was defined as the first serum lactate value obtained within 24 hours of hospital presentation. The SOFA score was calculated from the earliest available clinical and laboratory measurements recorded during the same 24-hour period. It incorporated respiratory function assessed through the PaO_2/FiO_2 ratio, coagulation assessed by platelet count, hepatic function assessed by bilirubin concentration, cardiovascular function assessed through blood pressure and vasopressor requirement, neurological function assessed by the Glasgow Coma Scale and renal function assessed by serum creatinine or urine output, where available. The primary outcome was all-cause in-hospital mortality during the index admission.

Data were entered, cleaned and analysed using IBM SPSS Statistics version 29.0 (IBM Corp., Armonk, NY, USA). Continuous variables were examined for normality using the Shapiro–Wilk test and were summarised as mean with standard deviation when normally distributed or median with interquartile range when distributions were non-normal. Categorical variables were presented as frequencies and percentages. Comparisons between survivors and non-survivors were performed using the independent-samples t-test for normally distributed continuous variables and the Mann–Whitney U test for non-normally distributed variables. Categorical variables were compared using the chi-square test or Fisher's exact test when expected cell counts were small. Where comparisons involved more than two groups, one-way analysis of variance or the Kruskal–Wallis test was applied, as appropriate. Binary logistic regression analysis was performed to examine factors associated with in-hospital mortality. Variables were initially assessed through univariable analysis, after which a multivariable model was fitted to determine the independent predictive contributions of admission SOFA score and serum lactate while adjusting for age, sex, diabetes mellitus, hypertension and chronic kidney disease. Adjusted odds ratios were reported with corresponding 95% confidence intervals. Model calibration was evaluated using the Hosmer–Lemeshow goodness-of-fit test, while explanatory performance was assessed using the Nagelkerke R^2 statistic.

Receiver operating characteristic curve analysis was used to evaluate the discriminative performance of the admission SOFA score, serum lactate and the combined logistic regression model. The combined model was represented by the predicted probability of in-

hospital mortality generated from the regression equation containing both SOFA score and lactate. Areas under the curve were calculated with 95% confidence intervals. Optimal cut-off values were identified using the Youden index, and the corresponding sensitivity, specificity, positive predictive value and negative predictive value were determined. Pairwise differences between areas under the receiver operating characteristic curves were assessed using the DeLong test. All statistical tests were two-sided, and a p-value of less than 0.05 was considered statistically significant.

RESULTS

A total of 210 adult patients with sepsis were included in the final analysis. Data screening identified no missing values in the variables used for the primary analysis, duplicate records or out-of-range observations. Repeat serum lactate measurements were available for 137 patients (65.2%) but were not included in the predictive models. The mean age of the study population was 57.1 ± 14.7 years, and 128 patients (61.0%) were male. Hypertension was present in 105 patients (50.0%), diabetes mellitus in 91 (43.3%), ischaemic heart disease in 44 (21.0%), chronic kidney disease in 35 (16.7%) and chronic obstructive pulmonary disease in 26 (12.4%). Pneumonia was the most frequent source of infection, occurring in 77 patients (36.7%), followed by urinary tract and intra-abdominal infections in 37 patients each (17.6%). Septic shock was present at admission in 65 patients (31.0%). Most patients were initially managed in the emergency department (n = 112, 53.3%), while 56 (26.7%) were admitted to the medical ward and 42 (20.0%) to the intensive care unit. The median admission SOFA score was 3.0 (IQR 1.0–7.0), and the median admission serum lactate concentration was 2.9 mmol/L (IQR 1.6–4.4). Vasopressor support was required in 69 patients (32.9%), mechanical ventilation in 19 (9.0%) and renal replacement therapy in 9 (4.3%). The median hospital stay was 7.0 days (IQR 6.0–9.8). Overall, 58 patients died during hospitalization, corresponding to an in-hospital mortality rate of 27.6%, while 152 patients (72.4%) survived to discharge.

Non-survivors had a significantly higher median SOFA score than survivors, at 8.5 (IQR 4.0–11.0) versus 2.0 (IQR 1.0–4.0; $p < 0.001$). Admission lactate was also higher among non-survivors, with a median concentration of 4.6 mmol/L (IQR 3.3–5.6) compared with 2.4 mmol/L (IQR 1.2–3.5) among survivors ($p < 0.001$). Non-survivors had a higher mean heart rate (116.1 ± 17.4 vs 99.7 ± 16.7 beats/min; $p < 0.001$), higher respiratory rate (25.5 vs 21.5 breaths/min; $p < 0.001$), lower mean arterial pressure (74.0 vs 87.5 mmHg; $p < 0.001$), lower Glasgow Coma Scale score (13.0 vs 15.0; $p < 0.001$) and lower 24-hour urine output (1087.8 ± 482.7 vs 1514.4 ± 370.3 mL; $p < 0.001$). Significant laboratory differences were also observed between the outcome groups. Non-survivors had lower platelet counts (174.6 ± 61.8 vs 234.7 ± 65.7 $\times 10^9$/L; $p < 0.001$), higher serum creatinine concentrations (2.1 vs 1.1 mg/dL; $p < 0.001$), higher bilirubin concentrations (1.3 vs 0.9 mg/dL; $p < 0.001$) and lower PaO_2/FiO_2 ratios (284.0 vs 394.0; $p < 0.001$). Septic shock occurred in 63.8% of non-survivors compared with 18.4% of survivors ($p < 0.001$). Mechanical ventilation was required in 24.1% versus 3.3% ($p < 0.001$), vasopressor support in 63.8% versus 21.1% ($p < 0.001$) and renal replacement therapy in 10.3% versus 2.0% ($p = 0.015$), respectively. Age, sex, body weight, infection source, hospital length of stay and individual chronic comorbidities did not differ significantly between survivors and non-survivors.

Mortality varied significantly according to the initial care setting. In-hospital mortality was 19.6% among patients managed in the emergency department, 21.4% among medical-ward patients and 57.1% among those admitted to the intensive care unit ($p < 0.001$). Intensive care unit patients had a median admission lactate of 4.6 mmol/L, compared with 2.4 mmol/L in the emergency department and 2.8 mmol/L in the medical ward ($p < 0.001$). Their median SOFA score was also higher at 9.0, compared with 2.0 in both other settings ($p < 0.001$). Septic shock was present in 66.7% of intensive care patients, compared with 20.5% and 25.0% of emergency-department and ward patients, respectively ($p < 0.001$). On univariable logistic regression, each one-point increase in SOFA score was associated with a 38% increase in the odds of in-hospital death (OR 1.38, 95% CI 1.25–1.52; $p < 0.001$), while each 1 mmol/L increase in admission lactate was associated with a twofold increase in mortality odds (OR 2.06, 95% CI 1.64–2.59; $p < 0.001$). Septic shock (OR 7.80, 95% CI 3.97–15.32), mechanical ventilation (OR 9.35, 95% CI 3.19–27.42), vasopressor support (OR 6.61, 95% CI 3.41–12.81) and renal replacement therapy (OR 5.29, 95% CI 1.30–21.57) were also significantly associated with mortality.

After adjustment for age, sex, diabetes mellitus, hypertension and chronic kidney disease, both admission lactate (adjusted OR 1.54 per mmol/L, 95% CI 1.13–2.08; $p = 0.006$) and SOFA score (adjusted OR 1.28 per point, 95% CI 1.13–1.45; $p < 0.001$) remained independently associated with in-hospital mortality. Age was also independently associated with mortality (adjusted OR 1.04 per year, 95% CI 1.01–1.07; $p = 0.003$). The model was statistically significant overall ($\chi^2[7] = 78.87$; $p < 0.001$), had a Nagelkerke R^2 of 0.452 and demonstrated adequate calibration (Hosmer–Lemeshow $\chi^2[8] = 2.59$; $p = 0.958$). Admission lactate predicted mortality with an AUC of 0.802 (95% CI 0.733–0.870). A cut-off of ≥3.6 mmol/L provided 74.1% sensitivity, 76.3% specificity, 54.4% positive predictive value and 88.5% negative predictive value. The SOFA score had an AUC of 0.805 (95% CI 0.735–0.875), with a cut-off of ≥7 yielding 63.8% sensitivity, 85.5% specificity, 62.7% positive predictive value and 86.1% negative predictive value. The combined SOFA and lactate model produced the highest AUC at 0.832 (95% CI 0.769–0.894), with 74.1% sensitivity, 81.6% specificity, 60.6% positive predictive value and 89.2% negative predictive value at a predicted-probability threshold of 0.31. However, the differences between the combined model and lactate alone ($p = 0.114$) or SOFA alone ($p = 0.139$) were not statistically significant. Mortality increased progressively across increasing SOFA and lactate categories, reaching 100% among patients with a SOFA score ≥13 and 81.8% among those with lactate concentrations >6.0 mmol/L (both trends $p < 0.001$).

Table 1. Baseline demographic, clinical, laboratory and severity characteristics of the study population (N = 210).

Characteristic	**Value (N = 210)**
Age, years	57.1 ± 14.7
Female sex	82 (39.0)
Weight, kg	68.7 ± 12.7
Diabetes mellitus	91 (43.3)
Hypertension	105 (50.0)
Chronic kidney disease	35 (16.7)
Chronic liver disease	10 (4.8)
Ischaemic heart disease	44 (21.0)
COPD	26 (12.4)
Active malignancy	13 (6.2)
Immunosuppression	14 (6.7)
Admission unit	
Emergency Department	112 (53.3)
Medical Ward	56 (26.7)
ICU	42 (20.0)
Infection source	
Pneumonia	77 (36.7)
Urinary tract	37 (17.6)
Intra-abdominal	37 (17.6)
Skin/soft tissue	24 (11.4)
CNS	10 (4.8)
Bloodstream	16 (7.6)
Unknown	9 (4.3)
Septic shock	65 (31.0)
Transferred to ICU	16 (7.6)
Temperature, °C	38.0 ± 1.0
Heart rate, bpm	104.3 ± 18.4
Respiratory rate, /min	22.0 (19.0–27.0)
MAP, mmHg	85.0 (75.0–92.0)
Glasgow Coma Scale	14.0 (13.0–15.0)
Urine output, mL/24h	1396.6 ± 446.3
Admission lactate, mmol/L	2.9 (1.6–4.4)
Haemoglobin, g/dL	10.4 ± 2.2
Leukocytes, $\times 10^9$/L	15.4 (9.7–18.9)
Platelets, $\times 10^9$/L	218.1 ± 69.9

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Creatinine, mg/dL	1.4 (0.9–2.2)
Bilirubin, mg/dL	1.0 (0.7–1.3)
PaO_2/FiO_2 ratio	374.5 (306.5–418.2)
Total SOFA score	3.0 (1.0–7.0)
Oxygen therapy	
None	35 (16.7)
Nasal cannula	123 (58.6)
Face mask	33 (15.7)
HFNC/NIV	19 (9.0)
Mechanical ventilation	19 (9.0)
Vasopressor support	69 (32.9)
Renal replacement therapy	9 (4.3)
ICU stay, days	0.0 (0.0–4.0)
Hospital stay, days	7.0 (6.0–9.8)

Table 2. Comparison of baseline characteristics between survivors (n = 152) and non-survivors (n = 58).

Characteristic	**Survivors (n = 152)**	**Non-survivors (n = 58)**	**Test statistic**	**p-value**
Age, years	56.0 ± 15.0	60.2 ± 13.5	t = -1.89	0.061
Female sex	63 (41.4)	19 (32.8)	$\chi^2 = 1.33$	0.249
Weight, kg	67.8 ± 12.5	71.1 ± 13.0	t = -1.68	0.094
Diabetes mellitus	67 (44.1)	24 (41.4)	$\chi^2 = 0.12$	0.724
Hypertension	78 (51.3)	27 (46.6)	$\chi^2 = 0.38$	0.537
Chronic kidney disease	25 (16.4)	10 (17.2)	$\chi^2 = 0.02$	0.890
Chronic liver disease	5 (3.3)	5 (8.6)	$\chi^2 = 2.63$	0.143
Ischaemic heart disease	32 (21.1)	12 (20.7)	$\chi^2 = 0.00$	0.954
COPD	21 (13.8)	5 (8.6)	$\chi^2 = 1.04$	0.307
Active malignancy	7 (4.6)	6 (10.3)	$\chi^2 = 2.38$	0.196
Immunosuppression	10 (6.6)	4 (6.9)	$\chi^2 = 0.01$	1.000
Admission unit			$\chi^2 = 22.95$	**< 0.001**
Emergency Department	90 (59.2)	22 (37.9)		
Medical Ward	44 (28.9)	12 (20.7)		
ICU	18 (11.8)	24 (41.4)		
Infection source			$\chi^2 = 8.77$	0.187
Pneumonia	54 (35.5)	23 (39.7)		
Urinary tract	21 (13.8)	16 (27.6)		
Intra-abdominal	31 (20.4)	6 (10.3)		
Skin/soft tissue	18 (11.8)	6 (10.3)		

CNS	8 (5.3)	2 (3.4)		
Bloodstream	12 (7.9)	4 (6.9)		
Unknown	8 (5.3)	1 (1.7)		
Septic shock	28 (18.4)	37 (63.8)	$\chi^2 = 40.44$	**< 0.001**
Transferred to ICU	10 (6.6)	6 (10.3)	$\chi^2 = 0.85$	0.387
Temperature, °C	38.0 ± 0.9	37.9 ± 1.0	t = 1.04	0.300
Heart rate, bpm	99.7 ± 16.7	116.1 ± 17.4	t = -6.28	**< 0.001**
Respiratory rate, /min	21.5 (19.0–26.0)	25.5 (21.2–29.0)	U = 2876.50	**< 0.001**
MAP, mmHg	87.5 (82.0–93.0)	74.0 (68.0–82.8)	U = 7031.00	**< 0.001**
Glasgow Coma Scale	15.0 (13.8–15.0)	13.0 (11.0–14.0)	U = 6604.00	**< 0.001**
Urine output, mL/24h	1514.4 ± 370.3	1087.8 ± 482.7	t = 6.08	**< 0.001**
Admission lactate, mmol/L	2.4 (1.2–3.5)	4.6 (3.3–5.6)	U = 1747.50	**< 0.001**
Haemoglobin, g/dL	10.4 ± 2.2	10.3 ± 2.0	t = 0.50	0.619
Leukocytes, $\times 10^9$/L	14.9 (9.2–18.2)	16.1 (10.7–19.8)	U = 3999.50	0.300
Platelets, $\times 10^9$/L	234.7 ± 65.7	174.6 ± 61.8	t = 6.02	**< 0.001**
Creatinine, mg/dL	1.1 (0.9–1.9)	2.1 (1.5–2.7)	U = 2364.00	**< 0.001**
Bilirubin, mg/dL	0.9 (0.6–1.2)	1.3 (1.1–1.7)	U = 1997.00	**< 0.001**
PaO_2/FiO_2 ratio	394.0 (345.8–433.2)	284.0 (222.8–353.8)	U = 6940.00	**< 0.001**
Total SOFA score	2.0 (1.0–4.0)	8.5 (4.0–11.0)	U = 1721.00	**< 0.001**
Oxygen therapy			$\chi^2 = 47.16$	**< 0.001**
None	32 (21.1)	3 (5.2)		
Nasal cannula	101 (66.4)	22 (37.9)		
Face mask	14 (9.2)	19 (32.8)		
HFNC/NIV	5 (3.3)	14 (24.1)		
Mechanical ventilation	5 (3.3)	14 (24.1)	$\chi^2 = 22.17$	**< 0.001**
Vasopressor support	32 (21.1)	37 (63.8)	$\chi^2 = 34.76$	**< 0.001**
Renal replacement therapy	3 (2.0)	6 (10.3)	$\chi^2 = 7.17$	**0.015**
ICU stay, days	0.0 (0.0–0.0)	3.5 (0.0–7.0)	U = 2910.00	**< 0.001**
Hospital stay, days	7.0 (6.0–10.0)	7.0 (5.0–9.0)	U = 5108.50	0.073

Table 3. Comparison of selected characteristics and outcome across admission settings: emergency department (n = 112), medical ward (n = 56) and intensive care unit (n = 42).

Characteristic	**ED (n = 112)**	**Ward (n = 56)**	**ICU (n = 42)**	**Statistic**	**p-value**
Age, years	56.8 ± 14.8	58.4 ± 14.9	56.5 ± 14.4	F = 0.28	0.752
Female sex	45 (40.2)	20 (35.7)	17 (40.5)	$\chi^2 = 0.36$	0.836
Septic shock	23 (20.5)	14 (25.0)	28 (66.7)	$\chi^2 = 31.68$	**< 0.001**
Admission lactate, mmol/L	2.4 (1.5–3.7)	2.8 (1.2–4.2)	4.6 (3.1–5.6)	H = 29.43	**< 0.001**

Total SOFA score	2.0 (1.0–5.0)	2.0 (1.0–5.5)	9.0 (4.0–12.0)	H = 38.77	**< 0.001**
MAP, mmHg	87.0 (80.0–93.0)	84.0 (77.8–92.0)	72.5 (63.5–84.2)	H = 30.39	**< 0.001**
Creatinine, mg/dL	1.1 (0.9–2.0)	1.2 (0.9–2.0)	2.1 (1.7–3.0)	H = 26.89	**< 0.001**
Mechanical ventilation	7 (6.2)	3 (5.4)	9 (21.4)	χ^2 = 9.82	**0.007**
Vasopressor support	26 (23.2)	17 (30.4)	26 (61.9)	χ^2 = 20.94	**< 0.001**
Renal replacement therapy	5 (4.5)	0 (0.0)	4 (9.5)	χ^2 = 5.33	0.070
Hospital stay, days	7.0 (6.0–9.0)	7.0 (6.0–9.0)	9.0 (6.0–11.0)	H = 4.02	0.134
In-hospital mortality	22 (19.6)	12 (21.4)	24 (57.1)	χ^2 = 22.95	**< 0.001**

Table 4. Univariable and multivariable binary logistic regression for predictors of in-hospital mortality.

Predictor	**Unadjusted OR (95% CI)**	**Wald**	**p**	**Adjusted OR (95% CI)**	**Wald**	**p**
Age (per year)	1.02 (1.00–1.04)	3.5	0.062	1.04 (1.01–1.07)	8.6	**0.003**
Female sex	0.69 (0.36–1.30)	1.3	0.250	0.71 (0.32–1.58)	0.7	0.401
Diabetes mellitus	0.90 (0.49–1.65)	0.1	0.724	0.93 (0.42–2.05)	0.0	0.858
Hypertension	0.83 (0.45–1.51)	0.4	0.537	0.62 (0.28–1.37)	1.4	0.235
Chronic kidney disease	1.06 (0.47–2.37)	0.0	0.890	0.46 (0.16–1.34)	2.0	0.156
Septic shock	7.80 (3.97–15.32)	35.6	**< 0.001**	—	—	—
Admission lactate (per mmol/L)	2.06 (1.64–2.59)	38.0	**< 0.001**	1.54 (1.13–2.08)	7.7	**0.006**
Total SOFA (per point)	1.38 (1.25–1.52)	43.5	**< 0.001**	1.28 (1.13–1.45)	14.4	**< 0.001**
Mechanical ventilation	9.35 (3.19–27.42)	16.6	**< 0.001**	—	—	—
Vasopressor support	6.61 (3.41–12.81)	31.2	**< 0.001**	—	—	—
Renal replacement therapy	5.29 (1.30–21.57)	5.4	**0.020**	—	—	—

Table 5. Receiver-operating-characteristic analysis for prediction of in-hospital mortality by admission lactate, Total SOFA score and the combined model.

Predictor	**AUC (95% CI)**	**Cut-off**	**Sens. %**	**Spec. %**	**PPV %**	**NPV %**	**Youden J**
Admission lactate (mmol/L)	0.802 (0.733–0.870)	≥ 3.6	74.1	76.3	54.4	88.5	0.505
Total SOFA score	0.805 (0.735–0.875)	≥ 7	63.8	85.5	62.7	86.1	0.493
Combined SOFA + lactate	0.832 (0.769–0.894)	0.31[P]	74.1	81.6	60.6	89.2	0.557

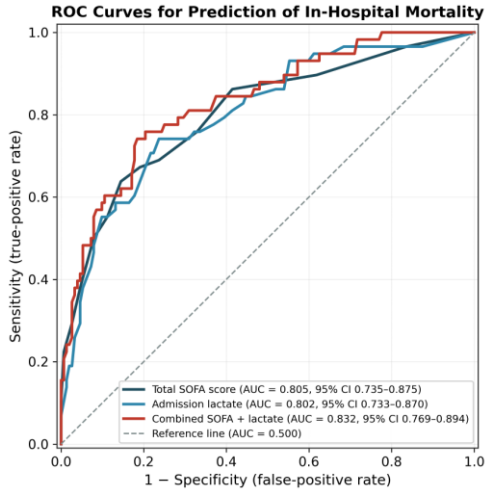

Figure 1. Receiver-operating-characteristic curves for admission lactate, Total SOFA score and the combined SOFA + lactate model for prediction of in-hospital mortality. The diagonal reference line denotes an area under the curve of 0.500 (no discrimination). The combined model showed the largest area under the curve (0.832).

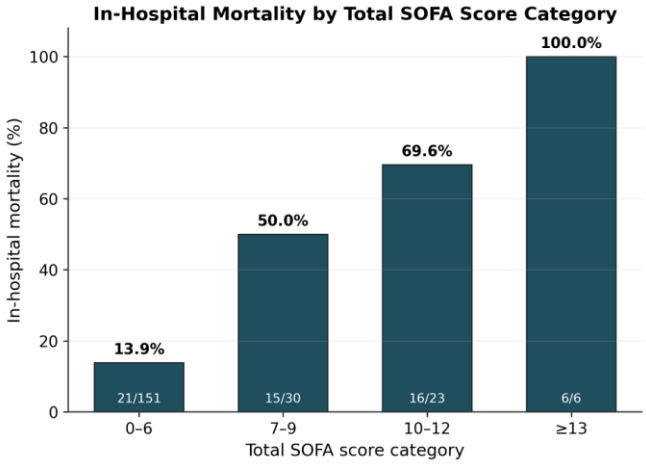

Figure 2. In-hospital mortality (%) across Total SOFA score categories. Numbers within each bar denote deaths/total patients in the category. Mortality increased monotonically with rising SOFA score (linear-by-linear association $p < 0.001$).

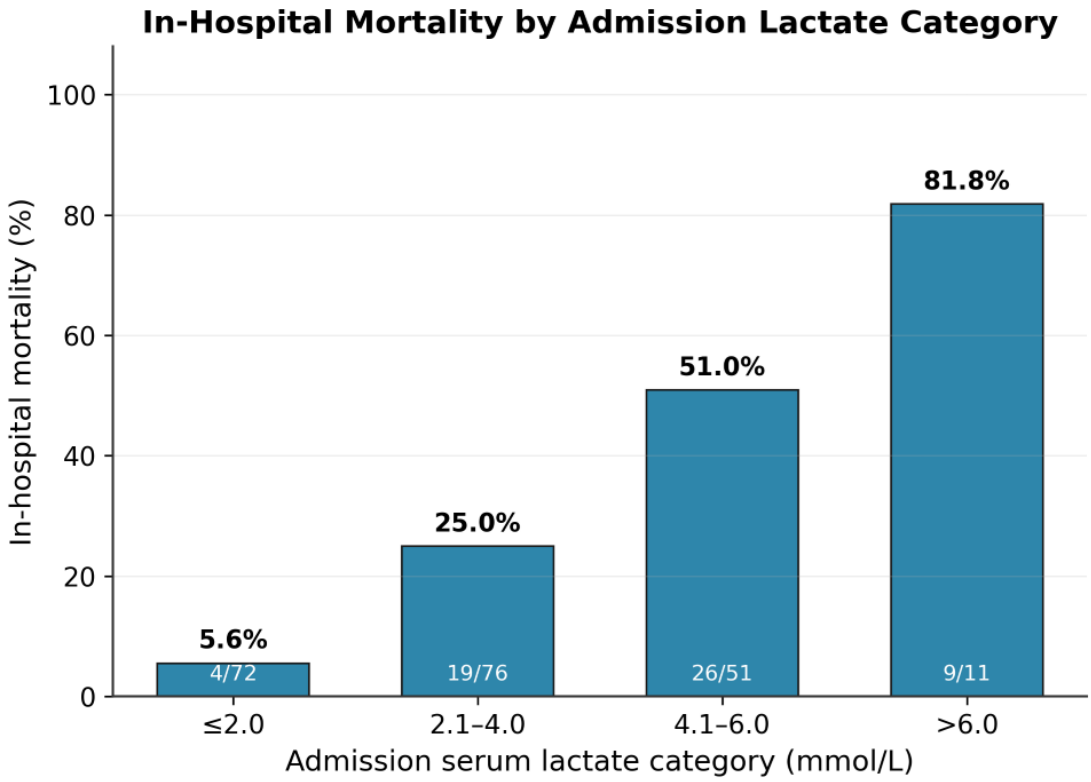

Figure 3. In-hospital mortality (%) across admission serum lactate categories. Numbers within each bar denote deaths/total patients in the category. Mortality increased monotonically with rising admission lactate (linear-by-linear association $p < 0.001$).

Discussion

The present study evaluated the prognostic value of the admission Sequential Organ Failure Assessment score and serum lactate concentration, both independently and in combination, for predicting in-hospital mortality among adults with sepsis. Both variables

remained independently associated with mortality after adjustment for demographic characteristics and major comorbidities. The combined model produced the highest discriminative performance, with an area under the receiver operating characteristic curve of 0.832, compared with 0.805 for SOFA score and 0.802 for admission lactate alone. Although the numerical improvement in discrimination did not reach statistical significance, the findings indicated that simultaneous assessment of organ dysfunction and metabolic disturbance provided a broader representation of sepsis severity than either measure considered in isolation (14-16). The observed in-hospital mortality rate of 27.6% was comparable with previously reported estimates from hospital-based sepsis populations. Global epidemiological data have shown that sepsis affects approximately 49 million people annually and contributes to almost 11 million deaths worldwide, accounting for a substantial proportion of global mortality (17). International sepsis guidelines and multicentre observational studies have reported hospital mortality rates ranging from approximately 20% to 35%, with considerable variation according to illness severity, treatment setting, access to critical care and the prevalence of septic shock (16). The mortality recorded in the current cohort therefore fell within the expected range, while also demonstrating the continuing burden of sepsis in a tertiary-care hospital despite the availability of contemporary antimicrobial and organ-supportive treatment.

Admission SOFA score emerged as a strong predictor of mortality. Non-survivors had substantially higher scores than survivors, and each one-point increase was associated with a 28% rise in the adjusted odds of in-hospital death. Mortality also increased progressively across SOFA categories and reached 100% among patients with scores of 13 or above. This pattern was consistent with the Sepsis-3 framework, in which increasing SOFA scores reflected greater organ dysfunction and a higher risk of death (1). Previous validation work across patients with suspected infection similarly demonstrated that increases in SOFA score were closely associated with hospital mortality and generally performed better than simpler bedside screening tools for prognostic assessment (15). The present findings therefore reinforced the clinical relevance of SOFA scoring during initial evaluation and supported its continued use in sepsis assessment, as recommended in international management guidelines (16). Admission serum lactate was also independently associated with mortality. Patients who died had markedly higher lactate concentrations than survivors, and the risk of death increased steadily across lactate categories. Mortality rose from 5.6% among patients with lactate concentrations of 2.0 mmol/L or lower to 81.8% among those with levels above 6.0 mmol/L. Earlier investigations have reported similar dose-response relationships and have shown that elevated lactate may identify high-risk patients even in the absence of overt hypotension (11). Other studies have demonstrated that lactate remained associated with mortality after adjustment for organ dysfunction and circulatory shock, indicating that it captured prognostic information not fully represented by clinical severity scores (14). These findings were biologically plausible because hyperlactataemia in sepsis may result from tissue hypoperfusion, adrenergic stimulation, accelerated glycolysis, mitochondrial dysfunction and reduced hepatic clearance rather than from anaerobic metabolism alone (18,19).

The principal contribution of the study was the assessment of the combined predictive performance of admission SOFA score and lactate. Both individual markers demonstrated good discrimination, while their combination produced the highest area under the curve and the highest Youden index. The combined model also achieved a negative predictive value of 89.2%, suggesting potential usefulness in identifying patients with a comparatively lower probability of in-hospital death at the observed mortality prevalence. Previous investigations have reported broadly comparable prognostic performance for SOFA score and lactate when used separately in septic populations (20). Other work has shown that combining organ-dysfunction scores with biochemical markers may improve mortality prediction in critically ill patients, although the magnitude of improvement has varied across settings and patient groups (21). The absence of a statistically significant difference between the combined model and the individual predictors required cautious interpretation. The improvement in area under the curve was modest, and the available sample may not have provided sufficient statistical power to detect small differences between correlated receiver operating characteristic curves. Consequently, the findings supported incremental rather than definitive superiority of the combined model. The numerical gain in discrimination may still have clinical relevance, particularly when both variables are already available during routine assessment, but it did not establish that the combined approach should replace either marker or be used as a stand-alone decision tool. Prognostic estimates should remain integrated with clinical examination, infection source, haemodynamic status, treatment response and the patient's overall condition.

The combined performance was also supported by the complementary biological roles of the two variables. SOFA score quantified dysfunction across respiratory, cardiovascular, hepatic, coagulation, neurological and renal systems, whereas lactate reflected metabolic stress, circulatory impairment and altered cellular function. These abnormalities may not develop simultaneously or to the same extent in every patient. A patient may develop elevated lactate before advanced organ dysfunction becomes evident, while another may have substantial organ failure with only moderate lactate elevation. Earlier research has similarly emphasized that lactate should be interpreted alongside haemodynamic and organ-dysfunction measures rather than as an isolated indicator of tissue perfusion (18). Age remained independently associated with mortality, whereas sex, diabetes mellitus, hypertension and chronic kidney disease did not. This finding suggested that acute physiological derangement contributed more directly to short-term outcome than the individual chronic conditions included in the model. However, the absence of significant associations with comorbidities should not be interpreted as evidence that they had no influence. Their effects may have been mediated through baseline organ function, frailty, treatment limitations or severity at presentation. Larger studies incorporating measures such as comorbidity burden, functional status and frailty may provide a more complete assessment of these relationships (19).

Patients admitted directly to the intensive care unit had higher SOFA scores, lactate concentrations, vasopressor requirements, mechanical ventilation use and mortality than those managed in the emergency department or medical ward. This finding was expected because admission location was closely linked to clinical severity and the need for organ support. It also demonstrated that the predictive variables reflected differences in illness intensity across care settings. Nevertheless, admission unit should not be regarded as an independent biological determinant of mortality, since triage decisions may be influenced by bed availability, referral practices and institutional protocols. Several strengths supported the study. The analysis included consecutive patients from emergency, ward and intensive care settings, used clearly defined Sepsis-3 eligibility criteria and assessed routinely available variables that could be applied in resource-limited hospitals. Mortality was evaluated using complementary methods, including regression modelling, receiver operating characteristic analysis, cut-off estimation and risk stratification across SOFA and lactate categories. The multivariable model also adjusted for relevant demographic and comorbidity-related factors and demonstrated acceptable calibration.

The findings should nevertheless be interpreted in light of important limitations. The single-centre design, non-probability sampling and relatively modest sample size limited generalisability and may have introduced selection bias. The study included only patients with complete SOFA, lactate and outcome data, which may have excluded individuals who died early or had limited laboratory testing. Lactate was assessed within the first 24 hours rather than at a strictly uniform time point, and serial lactate clearance could not be evaluated because repeat measurements were unavailable for a substantial proportion of patients. Residual confounding from frailty, infection severity, antimicrobial timing, resuscitation quality and treatment limitations was also possible. In addition, the combined model was internally assessed in the same cohort in which it was developed, creating a risk of optimistic performance estimates. Future investigations should therefore use larger multicentre prospective cohorts, standardized timing of lactate measurement and external validation of the combined model. Serial SOFA scores, lactate clearance and treatment-response variables should also be evaluated to determine whether dynamic assessment provides greater prognostic value than admission measurements alone. Comparisons with other validated severity scores and biomarkers, together with calibration and decision-curve analyses, would help establish whether the observed improvement translates into clinically meaningful changes in triage, monitoring and resource allocation.

CONCLUSION

The admission SOFA score and serum lactate level were both useful independent predictors of in-hospital mortality among patients with sepsis, while their combined assessment provided the most comprehensive approach to early risk stratification. By integrating the severity of organ dysfunction with the degree of metabolic and circulatory disturbance, the combined model offered clinically meaningful prognostic information using variables that are routinely available at hospital presentation. This approach may assist clinicians in identifying high-risk patients who require closer monitoring, timely resuscitation and early critical care support, particularly in resource-constrained settings. Although further multicentre validation is required, the findings support the practical use of SOFA score and admission lactate together as a simple and accessible tool for mortality risk assessment in sepsis.

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AUTHOR CONTRIBUTION

Author	Contribution
Dr Momina Mazhar Ali Khilji	Conceptualization, Methodology, Formal Analysis, Writing - Original Draft, Validation, Supervision
Dr Ambrina Qavi	Methodology, Investigation, Data Curation, Writing - Review & Editing
Dr Shariq Nawab	Investigation, Data Curation, Formal Analysis, Software
Dr Samiyya Rasool Abbasi	Software, Validation, Writing - Original Draft
Dr Zeeshan Ali	Formal Analysis, Writing - Review & Editing