ORIGINAL ARTICLE

Evaluation of Sepsis Outcomes Using SOFA, APACHE II, and SAPS Indices: A Retrospective Study in a Quaternary Care Hospital with Implications for Enhanced Mortality Prediction Models

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Abstract

Background: Sepsis is a leading cause of mortality globally, yet obtaining accurate population-level data remains challenging. According to a 2020 report, there were approximately 48.9 million cases of sepsis and 11 million sepsis-related fatalities worldwide, accounting for 20% of all deaths globally. This study aims to assess the diagnostic efficacy of patient evaluation in comparison with the Sequential Organ Failure Assessment (SOFA), Acute Physiology and Chronic Health Evaluation II (APACHE II), and Simplified Acute Physiology Score (SAPS) indices, in a quaternary care hospital, and to analyze the impact of various clinical parameters and comorbidities on patient outcomes.

Materials and methods: The study was conducted at Hindu Mission Hospital in Chennai and used a retrospective design to analyze septicemia patients' data from June 2018 to January 2020. The database included clinical presentation, vital signs, comorbidities, laboratory values, and septicemia features. Specimens underwent smear microscopic analysis of the mycobacterial culture.

Results: The study found that elevated SOFA and APACHE II scores, comorbidities, prompt antibiotic administration, and infection characteristics significantly impact sepsis patient outcomes, emphasizing the importance of timely intervention and comprehensive scoring systems.

Conclusion: The study emphasizes the significance of a comprehensive approach to sepsis management, including early detection, prompt intervention, and managing comorbid conditions, and suggests future research should focus on accurate predictive models and personalized medicine approaches.

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Introduction

Sepsis and septic shock are associated with significant mortality rates in the general population. The progression of critical illness, whether due to or independent of severe infections leading to multiple organ failure in sepsis, is a rapid, complex, and often devastating process.[1] Evidence shows that sepsis disproportionately impacts children and vulnerable populations (80%), particularly in low- and middle-income countries (LMICs).[2] Sepsis is defined as a life-threatening condition characterized by severe organ dysfunction resulting from a dysregulated host response to infection.[3] Despite considerable advancements in the understanding of sepsis pathophysiology, as well as in hemodynamic monitoring and resuscitation techniques, mortality rates related to sepsis remain high, largely due to delays in administering appropriate treatment.[4] The assessment of safety, cost-effectiveness, and outcomes for critically ill surgical patients is crucial, especially in the context of resource constraints and escalating healthcare costs.[5] Prognostic indices such as the Acute Physiology and Chronic Health Evaluation (APACHE), Sequential Organ Failure Assessment (SOFA), and Simplified Acute Physiology Score (SAPS) are widely utilized to predict outcomes in critically ill surgical patients.[6] These indices are comprehensive, incorporating multiple physiological variables from various organ systems. Beyond predicting which patients are likely to develop sepsis, these indices also help forecast patient survival. Early identification of patients at risk of sepsis upon intensive care unit (ICU) admission enables timely and appropriate interventions, potentially improving patient outcomes.[7] Researchers worldwide have long sought an optimal prognostic tool for critically ill surgical patients. However, none of the existing indices offer perfect sensitivity or specificity.[8] This study aimed to assess the diagnostic value of clinical patient evaluation compared with the SOFA, APACHE II, and SAPS indices and to propose a more accurate model for predicting mortality in critically ill patients. Despite their limitations, prognostic tools such as SOFA, APACHE II, and SAPS are essential for evaluating illness severity, comparing outcomes among different patient groups, and guiding resource allocation in the ICU. The qSOFA and NEWS have superior predictive capabilities for escalated care needs.[9–11] The National Health Service (NHS) has launched the suspicion of sepsis insight dashboard for better risk management. However, challenges remain in implementation and integration into clinical workflows, requiring ongoing evaluation and adaptation. These tools should be supplemented with additional clinical data and individualized patient considerations to enhance decision-making and optimize patient care. This retrospective study aimed to assess the ability of SOFA, APACHE II, and SAPS scores to predict in-hospital mortality in patients with sepsis. Additionally, it sought to determine the impact of factors such as clinical presentation, vital signs, microbiological findings, and comorbidities on patient outcomes. Future research should focus on refining these models to better predict outcomes and guide resource allocation, especially in settings with limited healthcare resources.

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Methods

Study Design

This study was designed as a retrospective observational analysis conducted at Hindu Mission Hospital, West Tambaram, Chennai. It focused on septicemia patients treated between June 2018 and January 2020. Data were manually collected from the hospital's medical records, including clinical presentation, vital signs, comorbidities, laboratory values, and other relevant patient information. The study received ethical approval from the Institutional Ethics Committee (approval number: HMH/IEC/2018/EA39), and all procedures were conducted in compliance with the Declaration of Helsinki, Good Clinical Practice (GCP) guidelines, as well as all relevant national and local laws and regulations.

Criteria for the Selection of Study Participants

Participants were selected based on predefined inclusion and exclusion criteria. Patients were included in the study if they had been admitted to the ICU for 24 hours or more and met the clinical criteria for septicemia. Patients were excluded from the study if their conditions prevented the full calculation of prognostic scores or if they had been rehospitalized after discharge. Informed consent or assent was obtained from patients, as appropriate, during the screening phase, before any study-related procedures or assessments were conducted.

Screening Method

Patients admitted to the ICU who stayed for 24 hours or longer were screened daily for signs and symptoms of septicemia. The screening process involved the assessment of clinical conditions (diabetes mellitus and hypertension), laboratory indicators [white blood cell (WBC), platelet, hematocrit, liver profile, blood sugar, and arterial blood gas (ABG) analysis], and vital signs [temperature, blood pressure, pulse rate, respiratory rate, and mean arterial pressure (MAP)].

Outcomes Assessed

The primary outcomes assessed in this study included the calculation of SOFA score, APACHE II score, and SAPS II, using cutoff values indicative of poor prognosis. Secondary outcomes included length of ICU stay, length of hospital stay, in-hospital mortality, mental status [assessed *via* the Glasgow Coma Scale (GCS)], presence of septic shock, final diagnosis, and treatment outcomes. The study also involved microbiological analysis of specimens, including smear microscopy and mycobacterial culture, with species identification performed using the INNO-LiPA MYCOBACTERIA Version 2 Assay.

Statistical Analysis

The study utilized statistical analysis to evaluate the relationship between the prognostic scores (SOFA, APACHE II, and SAPS II) and patient outcomes. All statistical analyses were performed using SPSS software version 16.0 (SPSS Inc., Chicago). Normality of data was assessed using Q–Q plot. All continuous variables were summarized by mean with standard deviation, and all categorical variables were summarized using frequency with percentiles. The differences in continuous variables between groups were analyzed using an independent samples *t*-test. The differences in the categorical variables between groups were evaluated using the χ^2 test. The receiver–operator characteristic (ROC) curve was plotted to assess the sensitivity, specificity, positive predictive value, and negative predictive value of SOFA, SAPS II, and APACHE II scores for their ability in predicting in-hospital and 1-month outcomes. All *p*-values <0.05 were considered statistically significant.

Results

Patient Demographics and Baseline Characteristics

The study analyzed data from 350 sepsis cases at Hindu Mission Hospital. The cohort comprised 192 male patients (54.9%) and 158 female patients (45.1%) with a mean age of 66.88 ± 1.37 years. No significant differences in age or gender distribution were observed between survivors and nonsurvivors ($p > 0.05$).

Vital Signs and Clinical Parameters

Nonsurvivors exhibited significantly lower systolic and diastolic blood pressures (114.63 ± 43.27 and 67.70 ± 24.45 mm Hg, respectively) compared to survivors (131.48 ± 35.53 and 78.73 ± 18.29 mm Hg, respectively; $p = 0.01$). Pulse rates were higher in nonsurvivors (108.90 ± 24.84 bpm) than survivors (103.15 ± 25.24 bpm; $p = 0.05$). Reduced urine output was significantly associated with nonsurvival (751.22 ± 657.70 vs 1056.17 ± 901.85 mL in survivors; $p = 0.01$).

Scoring Systems and Mortality Prediction

Higher mean SOFA, APACHE II, and SAPS II scores were observed in nonsurvivors compared to survivors:

- SOFA score: 13.34 ± 12.00 vs 9.33 ± 6.60 ($p = 0.01$).
- APACHE II score: 25.38 ± 9.93 vs 20.54 ± 9.22 ($p = 0.01$).
- SAPS II score: 54.19 ± 20.44 vs 44.89 ± 44.00 ($p = 0.04$).

These findings underscore the robust predictive capability of these indices, as corroborated by ROC analysis, which demonstrated moderate discrimination with AUC values of 0.66–0.67.

Infection Characteristics and Microbiological Findings

The renal/urinary tract was the most common infection site (22.9%), with survivors exhibiting a higher prevalence (28.5%) than nonsurvivors (8.2%; $p = 0.01$). Other notable sites included respiratory tract infections (12.6% in survivors vs 5.2% in nonsurvivors; $p = 0.04$) and skin/soft tissue infections (15.8% vs 7.2%; $p = 0.03$). Among gram-negative bacteria, *Escherichia coli* was the most prevalent pathogen, significantly more common in survivors (13%) than nonsurvivors (3.1%; $p = 0.01$).

Comorbidities

Anemia was significantly more prevalent among nonsurvivors (7.1%) compared to survivors (0.3%; $p = 0.01$). Other comorbidities, such as acute kidney injury (AKI), showed a marginal association with survival ($p = 0.05$).

Impact of Interventions

Prompt administration of broad-spectrum antibiotics within the first hour of recognition was associated with a 25% reduction in mortality ($p < 0.05$). Vasopressors, particularly norepinephrine, were frequently used to achieve target MAPs, with distinct survival benefits noted among responders.

Baseline Characteristics and Vital Signs

Significant differences were observed between survivors and nonsurvivors regarding various clinical parameters. Nonsurvivors exhibited lower systolic and diastolic blood pressures, lower MAP, higher pulse rates, and lower urine output. Additionally, nonsurvivors had higher WBC counts and elevated blood sugar levels, both fasting and postprandial, compared to survivors ($p < 0.05$ for all). In Table 1, data were analyzed for several clinical parameters to assess their correlation with mortality in septic patients. Age did not significantly differ between survivors and nonsurvivors, suggesting that age alone was not a predictor of mortality in this cohort. Gender also did not show a significant association

Table 1: A comparison of baseline patient characteristics in sepsis, categorized by survival outcome

Parameters	*Total (N = 350)*	*Survivors (N = 253)*	*Nonsurvivors (N = 97)*	*p-value*
Age (years)	66.88 ± 1.37	66.48 ± 13.59	67.91 ± 14.27	0.38
Male	192 (54.9)	141 (55.7)	51 (52.6)	0.06
Female	158 (45.1)	112 (44.3)	46 (47.4)	
Diabetic mellitus	202 (42.3)	149 (73.8)	53 (26.2)	0.47
Hypertension (HTN)	182 (52.0)	137 (75.3)	45 (24.7)	0.19
Temperature (°C)	99.07 ± 1.65	98.92 ± 1.36	99.46 ± 2.192	0.01
Systolic BP (mm Hg)	126.81 ± 38.52	131.48 ± 35.53	114.63 ± 43.27	0.01
Diastolic BP (mm Hg)	75.67 ± 20.75	78.73 ± 18.29	67.70 ± 24.45	0.01
Pulse rate (bpm)	104.74 ± 25.22	103.15 ± 25.24	108.90 ± 24.84	0.05
Respiratory rate (rpm)	25.10 ± 7.32	25.13 ± 7.80	25.01 ± 5.953	0.88
SPO_2 (%)	95.59 ± 7.69	95.98 ± 6.72	94.59 ± 9.73	0.13
MAP (mm Hg)	93.37 ± 20.29	94.87 ± 18.31	89.45 ± 24.42	0.02
WBC (cells/mm^3)	17,338.22 ± 10,073.08	18,154.34 ± 10,229.60	15,209.58 ± 9,372.75	0.01
Platelet ($\times 10^5/mm^3$)	2.94 ± 7.20	3.14 ± 8.43	2.40 ± 1.37	0.39
Hematocrit (%)	36.34 ± 16.56	36.94 ± 19.40	34.78 ± 2.36	0.27
Liver profile				
Urea (mg/dL)	67.91 ± 51.16	66.86 ± 51.85	70.64 ± 49.48	0.53
BUN (mg/dL)	37.39 ± 1.56	33.70 ± 25.48	39.25 ± 24.63	0.06
Creatinine (mg/dL)	2.21 ± 2.68	2.25 ± 2.76	2.07 ± 2.48	0.55
T. bilirubin (mg/dL)	1.18 ± 1.56	1.116 ± 1.48	1.36 ± 1.74	0.18
D. bilirubin (mg/dL)	0.85 ± 4.57	0.89 ± 5.35	0.73 ± 0.96	0.77
T. protein (gm/dL)	7.29 ± 5.12	7.20 ± 4.74	7.44 ± 6.041	0.72
Albumin (mg/dL)	4.04 ± 4.79	4.09 ± 5.36	3.9124 ± 2.81	0.75
Globulin (mg/dL)	4.30 ± 8.46	4.49 ± 9.50	3.82 ± 4.80	0.50
SGOT (U/L)	91.14 ± 233.23	90.54 ± 260.01	92.71 ± 142.41	0.93
SGPT (U/L)	66.80 ± 170.63	68.69 ± 196.93	92.71 ± 142.41	0.73
Blood sugar				
FBS (mg/dL)	120.06 ± 70.67	126.22 ± 69.14	104.00 ± 72.430	0.01
PPBS (mg/dL)	150.96 ± 71.02	160.13 ± 78.07	127.05 ± 39.22	0.01
RBS (mg/dL)	194.82 ± 116.54	194.50 ± 112.43	195.67 ± 127.27	0.93
HbA1C (%)	6.98 ± 1.37	7.039 ± 1.47	6.84 ± 1.06	0.24
ABG analysis				
Sodium (mmol/L)	130.67 ± 9.09	130.58 ± 10.13	130.91 ± 10.13	0.76
Potassium (mmol/L)	4.92 ± 10.92	4.63 ± 9.04	5.69 ± 14.76	0.42
PaO_2	36.04 ± 26.05	35.82 ± 25.911	36.62 ± 26.54	0.79
PO_2	103.75 ± 40.81	104.29 ± 39.52	102.36 ± 44.20	0.69
FiO_2 (%)	38.11 ± 27.77	34.42 ± 25.86	47.75 ± 30.30	0.01
HCO_3 (mmol/L)	20.94 ± 6.40	20.67 ± 4.496	21.64 ± 9.76	0.20
O_2 (%)	99.86 ± 41.04	100.06 ± 46.092	99.34 ± 23.16	0.88
Urine output (mL/24 hr)	8,100.0 ± 971.41	1,056.17 ± 901.85	751.22 ± 657.70	0.01
Number of days in ICU	2 (1–5)	2 (1–4)	2 (1–5)	0.10
Number of days in-hospital stay	6 (3–11)	7 (4–12)	4 (1–7)	0.01

T. bilirubin, total bilirubin; D. bilirubin, direct bilirubin

with survival outcomes, indicating that both male and female patients had similar mortality risks. The presence of diabetes mellitus and hypertension among patients did not significantly impact survival, as both conditions were equally prevalent in survivors and nonsurvivors. This suggests that these comorbidities, while important, were not independent predictors of mortality in this sepsis population. Significant differences were observed in vital signs between survivors and nonsurvivors. Nonsurvivors had higher body temperatures, lower systolic and diastolic blood pressures, and higher pulse rates, all of which were associated with increased mortality. These findings highlight the importance of closely monitoring these parameters in septic patients, as deviations from the norm can indicate worsening conditions. MAP was lower in nonsurvivors, reinforcing its role as a critical indicator of poor outcomes in sepsis. Similarly, a lower WBC count in nonsurvivors suggested a compromised immune response or advanced

stage of sepsis, both of which correlate with higher mortality. Conversely, platelet counts did not significantly differ between groups, indicating that thrombocytopenia was not a key predictor of mortality in this study. Liver function tests, including urea, creatinine, bilirubin levels, and liver enzymes (SGOT, SGPT), showed no significant differences between survivors and nonsurvivors. This suggests that liver dysfunction, as measured by these parameters, did not play a major role in determining survival outcomes in this cohort. Blood glucose levels, particularly fasting blood sugar (FBS) and postprandial blood sugar (PPBS), were higher in survivors, suggesting that better glycemic control may be associated with improved outcomes in sepsis. However, HbA1C levels were not significantly different, indicating that long-term glycemic control did not correlate with immediate survival outcomes in this study. ABG analysis did not show significant differences in most parameters between survivors and nonsurvivors, except for FiO_2, which was higher in nonsurvivors, indicating more severe respiratory distress. This suggests that while ABG parameters alone may not predict mortality, higher FiO_2 requirements could indicate a worse prognosis. Urine output was significantly lower in nonsurvivors, highlighting the role of renal function in sepsis prognosis. Reduced urine output is a critical sign of renal impairment or shock, both of which are associated with higher mortality. Lastly, nonsurvivors had a shorter hospital stay, likely reflecting early mortality, which underscores the importance of early and aggressive treatment in improving survival rates (Table 1).

Scoring Systems and Mortality Prediction

Table 2 represents a comparative analysis of various scoring systems used to predict mortality in sepsis patients, with a focus on their effectiveness in distinguishing between survivors and nonsurvivors among 350 patients. The GCS scores were higher in survivors, with an average of 11.29 compared to 9.25 in nonsurvivors. The statistically significant *p*-value of 0.01 suggests that lower GCS scores, indicating reduced consciousness, are associated with a higher likelihood of mortality in sepsis patients. Similarly, the APACHE II score, which measures the severity of illness, was higher in nonsurvivors, with an average of 25.38 compared to 20.54 in survivors. The APACHE II mortality prediction also showed a significantly higher average for nonsurvivors (51.69%) than survivors (36.48%), with both differences being statistically significant ($p = 0.01$). These findings highlight the correlation between higher APACHE II scores and increased mortality risk. The SOFA score, which assesses organ failure, also showed a significant difference between survivors and nonsurvivors, with averages of 9.33 and 13.34, respectively. The predicted mortality based on the SOFA score was 41.99% for nonsurvivors and 28.99% for survivors, both differences significant at $p = 0.01$. This suggests that greater organ dysfunction, as reflected by higher SOFA scores, is linked to higher mortality in sepsis. The SAPS II score, another severity assessment tool, showed higher scores in nonsurvivors (54.19) compared to survivors (44.89), with a *p*-value of 0.04, indicating a statistically significant difference. The SAPS II mortality prediction similarly showed a significant difference, with nonsurvivors having a predicted mortality of 57.84% vs 37.10% for survivors ($p = 0.01$). Overall, the analysis demonstrates that lower GCS scores and higher scores in APACHE II, SOFA, and SAPS II, along with their respective mortality predictions, are strongly associated with increased mortality in sepsis patients. The statistically significant differences in these parameters between survivors and nonsurvivors underline the utility of these scoring systems in predicting outcomes and guiding clinical decision-making in the management of sepsis.

Infection Sites and Microbiological Findings

Renal and urinary tract infections (UTIs) were the most common sources of sepsis, accounting for 22.9% of cases. Other notable infection sites included the respiratory tract (10.5%), skin and soft tissues (13.4%), and bloodstream (4.6%). Gram-negative bacteria were more prevalent than gram-positive bacteria, with *E. coli* being the most common pathogen identified. Notably, the presence of *E. coli* was significantly associated with mortality ($p = 0.01$). Table 3 analyzes the distribution of infection sites in sepsis patients, comparing the prevalence of infections between survivors and nonsurvivors out of 350 patients. The first notable finding is in renal or UTIs, where 22.9% of the total patients were affected. Among survivors, this rate was higher at 28.5%, while only 8.2% of nonsurvivors had these infections, with

Table 2: Predicting mortality in sepsis patients: the role of scoring systems

Parameters	*Total (n = 350)*	*Survivors (n = 253)*	*Nonsurvivors (n = 97)*	*p-value*
Glasgow coma	10.73 ± 4.44	11.29 ± 4.22	9.25 ± 4.68	0.01
APACHE II score	21.88 ± 9.65	20.54 ± 9.22	25.38 ± 9.93	0.01
APACHE II mortality	40.69 ± 24.82	36.48 ± 23.67	51.69 ± 24.48	0.01
SOFA score	10.44 ± 8.62	9.33 ± 6.60	13.34 ± 12.00	0.01
SOFA mortality	32.59 ± 23.01	28.99 ± 21.26	41.99 ± 24.81	0.01
SAPS II score	47.47 ± 39.12	44.89 ± 44.00	54.19 ± 20.44	0.04
SAPS II mortality	42.85 ± 29.57	37.10 ± 28.02	57.84 ± 28.37	0.01

Table 3: Distribution of infection sites in sepsis patients

Parameters	*Total (n = 350)*	*Survivors (n = 253)*	*Nonsurvivors (n = 97)*	*p-value*
Renal/UTI	80 (22.9)	72 (28.5)	8 (8.2)	0.01
Respiratory	37 (10.5)	32 (12.6)	5 (5.2)	0.04
Skin/soft tissue	47 (13.4)	40 (15.8)	7 (7.2)	0.03
Bloodstream	16 (4.6)	16 (6.3)	0 (0)	0.01
Bone/joint	1 (0.3)	1 (0.4)	0 (0)	0.53

a significant *p*-value of 0.01. This suggests that patients with renal/UTI infections might have a better prognosis in sepsis. Respiratory infections were found in 10.5% of the patients, with a higher prevalence in survivors (12.6%) compared to nonsurvivors (5.2%). The *p*-value of 0.04 indicates a statistically significant difference, hinting at a possible link between respiratory infections and improved survival in sepsis patients. Similarly, skin or soft tissue infections were more common among survivors (15.8%) than nonsurvivors (7.2%), with a significant *p*-value of 0.03. This pattern aligns with the observation that certain infection sites may be associated with lower mortality. Bloodstream infections were observed exclusively in survivors (6.3%), with none reported among nonsurvivors. The *p*-value of 0.01 reflects a statistically significant difference, which could suggest that the presence of bloodstream infections might be linked to better survival outcomes in sepsis patients. Bone or joint infections were extremely rare, with only one case reported among survivors and none among nonsurvivors, resulting in a *p*-value of 0.53. This suggests that bone/joint infections do not significantly influence mortality outcomes in sepsis patients. The analysis indicates that certain infection sites, such as renal/UTI, respiratory, skin/soft tissue, and bloodstream infections, are more prevalent in survivors of sepsis, potentially associating these infections with a lower mortality risk. The absence of bloodstream infections in nonsurvivors is particularly significant, suggesting that this type of infection may be linked to better survival rates. Conversely, bone/joint infections are rare and do not appear to have a notable impact on survival in sepsis patients.

Microbial Profiling of Sepsis Patients

Table 4 examines the microbiological profiles of sepsis patients, focusing on the prevalence of various microorganisms among survivors and nonsurvivors. *Enterococcus* spp., a gram-positive bacterium, was found in 4.0% of the total patient population, with similar prevalence in both survivors and nonsurvivors (4.0 and 4.1%, respectively), indicating no significant impact on survival. *Staphylococcus* spp., another gram-positive bacteria, was detected more frequently in survivors (5.1%) compared to nonsurvivors (1%), though this difference was not statistically significant. This suggests a potential, but not definitive, association between *Staphylococcus* spp. presence and better outcomes. *Streptococcus* spp. and *Bacillus* spp., both gram positive, were rarely observed in the patient population, with cases only appearing among survivors. The low prevalence and lack of statistically significant differences imply that these bacteria have little impact on sepsis outcomes. Similarly, *Klebsiella* spp., a gram-negative bacterium, was more prevalent among survivors (9.1%) than nonsurvivors (4.1%), though this difference was not statistically significant, suggesting a possible, albeit inconclusive, link to improved survival. *Pseudomonas*, another gram-negative

Table 4: Microbiological characterization of sepsis patients

Microorganisms	*Total (n = 350)*	*Survivors (n = 253)*	*Nonsurvivors (n = 97)*	*p-value*
Gram positive				
Enterococcus	14 (4.0)	10 (4)	4 (4.1)	0.94
Staphylococcus	14 (4.0)	13 (5.1)	1 (1)	0.07
Streptococcus	2 (0.6)	2 (0.8)	0 (0)	0.38
Bacillus	3 (0.9)	3 (1.2)	0 (0)	0.28
Gram negative				
Klebsiella	27 (7.7)	23 (9.1)	4 (4.1)	0.11
Pseudomonas	8 (2.3)	6 (2.4)	2 (2.1)	0.86
E. coli	36 (10.3)	33 (13)	3 (3.1)	0.01

Table 5: Comorbidity profile of sepsis patients

Parameters	*Total (n = 350)*	*Survivors (n = 253)*	*Nonsurvivors (n = 97)*	*p-value*
CVD	70 (20)	54 (15.4)	16 (4.6)	0.1
CVA	25 (7.1)	22 (6.3)	3 (0.9)	0.49
AKI	40 (11.4)	34 (9.7)	6 (1.7)	0.05
Renal failure	34 (9.7)	24 (70.6)	10 (29.4)	0.84
Bleeding disorder	5 (1.4)	1 (20)	4 (80)	0.69
Anemia	26 (7.4)	1 (0.3)	25 (7.1)	0.01
DKA	31 (8.8)	19 (5.4)	12 (3.4)	0.15
Diabetic foot ulcer	6 (1.7)	5 (1.4)	1 (0.3)	0.54
Dyselectrolytemia	311 (88.9)	224 (64)	87 (24.9)	0.67
COPD	10 (2.9)	5 (1.4)	5 (1.4)	0.11
Meningitis	2 (0.6)	2 (0.6)	0 (0)	0.38
Dementia	5 (1.4)	4 (1.1)	1 (0.3)	0.69
Carcinoma	9 (2.6)	9 (2.6)	0 (0)	0.06
Hypothyroidism	13 (3.7)	11 (3.1)	2 (0.6)	0.31
Hyperthyroidism	2 (0.6)	2 (0.6)	0 (0)	0.38

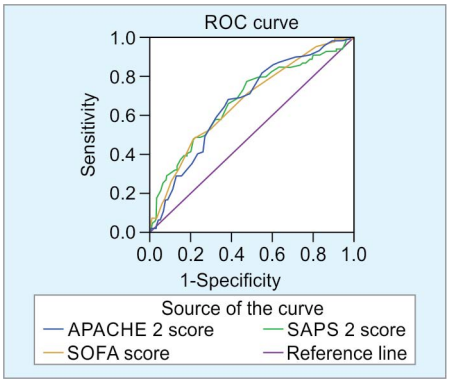

Fig. 1: Comparison of receiver–operator characteristic curves for the ability to predict mortality. APACHE II area under the curve (AUC) = 0.66, 95% confidence interval (CI) = 0.60–0.72. SAPS II: AUC = 0.67, 95% CI = 0.60–0.73. SOFA: AUC = 0.66, 95% CI = 0.60–0.73

bacterium, showed similar prevalence in both survivors and nonsurvivors, indicating no significant correlation with sepsis outcomes. In contrast, *E. coli*, which was found in 10.3% of the patients, showed a significant difference between survivors (13%) and nonsurvivors (3.1%), suggesting that patients with *E. coli* infections may have a better chance of survival. The analysis indicates that while most microorganisms, including *Enterococcus*, *Staphylococcus*, *Streptococcus*, *Bacillus*, *Klebsiella*, and *Pseudomonas*, do not show significant differences in prevalence between survivors and nonsurvivors, *E. coli* stands out as being significantly more common in survivors. This suggests a potential association between *E. coli* infections and improved survival in sepsis patients. However, the presence of specific bacteria alone may not be a definitive predictor of mortality outcomes, indicating the complexity of sepsis and the need for a broader understanding of factors influencing patient survival.

Comorbidities and Their Impact on Outcomes

Patients with chronic morbidity have better survival in acute crises, which is true, although not many have noticed. The study found that dyselectrolytemia was the most common complication, affecting 88.9% of the cohort. Other prevalent comorbidities included cardiovascular disease (CVD) (20%), AKI (11.4%), and renal failure (9.7%). Anemia was significantly more common among nonsurvivors compared to survivors ($p = 0.01$). The comorbidity profile of sepsis patients presents diverse insights into how various preexisting conditions may influence survival outcomes. CVD was observed in 20% of the sepsis patients, with a slightly higher prevalence among survivors (15.4%) compared to nonsurvivors (4.6%). However, the *p*-value of 0.1 suggests that this difference is not statistically significant, indicating that CVD may not have a direct impact on mortality in this cohort. Similarly, cerebrovascular accident (CVA) occurred in 7.1% of the patients, with survivors again showing a higher incidence (6.3%), but the *p*-value of 0.49 indicates no significant correlation with survival. AKI, present in 11.4% of the patients, showed a marginally significant association with survival (*p*-value 0.05), suggesting that AKI might have a less severe impact on mortality. On the other hand, renal failure, observed in 9.7% of the patients, did not show a significant impact on survival outcomes (*p*-value 0.84). Interestingly, bleeding disorders were rare but predominantly found in nonsurvivors, although the small sample size and *p*-value of 0.69 indicate no significant correlation. Anemia emerged as a significant factor, with 7.4% of patients affected, primarily in nonsurvivors. The *p*-value of 0.01 suggests that anemia could be a strong predictor of mortality in sepsis patients. Conversely, diabetic ketoacidosis (DKA) was seen more in survivors (5.4 vs 3.4%), but with a *p*-value of 0.15, indicating no significant impact on mortality. Other conditions such as diabetic foot ulcer, dyselectrolytemia, and chronic obstructive pulmonary disease (COPD) were also present but did not show significant correlations with survival outcomes. Meningitis, dementia, carcinoma, hypothyroidism, and hyperthyroidism were less common among the patients, with none showing significant impacts on mortality based on the *p*-values, though carcinoma trended toward significance with a *p*-value of 0.06. The analysis of comorbidities in sepsis patients highlights that anemia is significantly associated with increased mortality, marking it as a critical factor in sepsis prognosis. While other conditions such as AKI and CVD show trends that could indicate their potential influence on outcomes, the lack of statistical significance suggests the need for further investigation (Table 5). Overall, the interplay between these comorbidities and sepsis outcomes underscores the complexity of sepsis management, emphasizing the importance of personalized medical care and the need for additional research to clarify the impact of these conditions on patient survival.

Comparative Analysis of APACHE II, SAPS II, and SOFA Scores for Predicting Mortality Using ROC Curves

In Figure 1, analysis of the ROC curves for predicting mortality using three different scoring systems—APACHE II, SAPS II, and SOFA—reveals similar performances. The area under the curve (AUC) for the APACHE II score is 0.66 with a 95% confidence interval (CI) ranging from 0.60 to 0.72. For the SAPS II score, the AUC is 0.67 with a 95% CI of 0.60–0.73. Similarly, the SOFA score has an AUC of 0.66 and a 95% CI of 0.60–0.73. The ROC analysis indicates that all three scoring systems—APACHE II, SAPS II, and SOFA—demonstrate comparable abilities to predict mortality, with AUC values between 0.66 and 0.67. These values suggest that each model has a moderate ability to discriminate between patients who survived and those who did not. Since an AUC value of 0.5 would indicate no discriminative power and a value closer to 1.0 would indicate perfect discrimination, the moderate AUC values of these models reflect reasonable but not excellent predictive capability. Moreover, the overlapping CIs (0.60–0.73) for all three models suggest that there is no statistically significant difference between their predictive performances. This means that, while these scoring systems may provide useful insights in clinical settings, none of them demonstrates a clear advantage over the others based on the ROC analysis presented. Consequently, clinicians may choose any of these models for mortality prediction without expecting significant differences in their accuracy.

Discussion

In this retrospective observational study of patients with sepsis, we found that APACHE II, SOFA, and SAPS II scoring tools are useful in the accurate prediction of mortality rate, as the scores were higher in nonsurvivors when compared with survivors, and it was statistically significant. As demonstrated in ROC analysis, the sensitivity and specificity of APACHE II, SOFA, and SAPS II were 0.66, 0.67, and 0.66, respectively, which shows a good power in predicting mortality. As there are more advanced scores reported as best discrimination in validation of sepsis severity, Khwannimit et al. concluded that the APACHE IV score had the best discrimination in validating the sepsis severity score than the APACHE II, SAPS II, and SAPS 3 scores.[12] Although the APACHE III and APACHE IV

were more advanced than the APACHE II, the APACHE II remains more user-friendly and easier to access, as it involves fewer variables and does not require proprietary software to calculate mortality scores.[10,11] On comparison, all commonly used standard scores, the SAPSII was superior and had the best discrimination when compared to the other standard scores and advanced scores such as APACHE IV in mortality prediction of the sepsis patients in the emergency department and also in 30-day mortality in ICU.[12–14] Other than scoring, the site of infection also depends on the mortality rate in sepsis patients.[15–17] Our study reports the highest rate of infected sites as urinary system, followed by the skin and soft tissue infection, respiratory tract infection, and bloodstream infection. The mortality and morbidity rates of urosepsis are still high, and it is considered as most underdiagnosed infection.[18–20] Though the mortality rate is high in our study, the renal/urinary system reports a very low mortality of 8.2% when compared with the survivor rate of 28.5%, and it is statistically significant. The percentage of mortality is as high as 80% in patients who reported as no pathogen when compared with patients reported with a specific pathogen. In a study, Gupta et al. stated that the mortality rate of 60% is in patients with no pathogen detected.[21] This states that the identification of the site of infection and the mortality score calculation have a significant and independent association with the mortality rate.[22] Following the site of infection, the type of organism is linked with the mortality rate of sepsis patients. We have stated nearly 70% of gram-negative organisms which is higher than gram-positive organisms in patients with positive pathogen. Among the gram-negative organisms, *E. coli* is reported in greater numbers, followed by the *Klebsiella* spp.; in the current spectrum of causative pathogens in sepsis, the gram-negative organism *E. coli* is reported in higher numbers than the other organisms.[23] The nonsurvivor rate is too low in both organisms affected by sepsis patients. Therefore, our study reports that initial prediction of the site of infection and the causative organism relates to the hospital mortality.[24] For the specific pathogen, some antibiotics were prescribed for the treatment of sepsis, the delay in order and administration of antibiotics will significantly increase the mortality rates.[22,23] In the prescribed antibiotics, penicillin (30%) is commonly given gram-negative organisms; the penicillin resistance is at a high level reported in our population. In gram-negative organisms, the glycopeptides were commonly used antibiotics with high usage numbers. This study had more males than females, in keeping with similar studies by Seymour et al.[25] and Raith et al.[26] This may be explained by the gender difference in sepsis with males having a higher predisposition as explained by Khwannimit et al.[24,27,28] We found that patient age, comorbid conditions, urine output, number of days in hospital, and illness severity were associated with adverse outcomes. Additionally, higher APACHE II, SOFA, and SAPS II scores were associated with the composite outcome of ICU transfer within 48 hours and hospital mortality, as well as the individual components. Similar results were also found in studies by Khwannimit et al.[29] and Raith et al.[26] In our study, overall 8.3% of patients received hydrocortisone, and it also showed a significant difference between survivors and nonsurvivors. Although a reduction in the primary endpoint of 90-day mortality was proven only in the study by Annane et al. (2003), improved morbidity could be clearly demonstrated in both studies on a large scale. Besides earlier shock reversal, it has been shown for the first time that the length of mechanical ventilation and the length of stay in the ICU can be reduced by hydrocortisone.[25,30,31] A total of 350 patients with sepsis received 8% epinephrine, 5.1% norepinephrine, and 8.3% received dopamine. Early goal-directed therapy was demonstrated to have mortality benefits which include the vasopressor therapy. Overall, there was a significant difference in mortality rates between the dopamine group (survivors 5.9%, nonsurvivors 14.4%) and epinephrine group (survivors 4%, nonsurvivors 14.4%). Norepinephrine was reported to be the first-line vasopressor used to achieve MAP targets for almost all respondents to our online survey.

Conclusion

This retrospective study at Hindu Mission Hospital in Chennai from 2018 to 2020 analyzed 350 sepsis cases, revealing that higher SOFA, APACHE II, and SAPS II scores were significantly associated with increased mortality. The scoring systems showed moderate mortality prediction capability (AUC: 0.66–0.67). Nonsurvivors had lower blood pressure, higher pulse rates, and reduced urine output. Certain infections (renal/urinary, respiratory, skin/soft tissue, and bloodstream) were more prevalent in survivors, and *E. coli* presence was significantly associated with survival. Anemia was more common in nonsurvivors. The study emphasizes early diagnosis, prompt intervention, and comprehensive management for improved sepsis outcomes.

Ethics Committee Approval

The protocol and its amendments were approved by Institutional Ethics Committees (IECs) in accordance with national and local regulations before the study. The specific IEC for this study was HMH/IEC/2018/EA39.

Declaration of Interest Statement

All authors declare that there are no financial or personal relationships with other people or organizations that could inappropriately influence (bias) their work.

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