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Mortality Prediction in Intensive Care Unit: A Comparative Analysis

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Abstract

The primary purpose of an intensive care unit is to monitor and care for patients who require close and constant attention due to the critical nature of their medical conditions. Despite continuous monitoring and the provision of specialized care with advanced equipment, the mortality rate in the intensive care unit remains high. We aimed to compare the effectiveness of the Sequential Organ Failure Assessment (SOFA) and Simplified Acute Physiology Score (SAPS II) in mortality prediction. The study conducted a comparative descriptive analysis in the Intensive Care Unit, involving 60 eligible participants through convenience sampling. They were allocated into two groups: Group I (n=34) and Group II (n=34). Mortality prediction evaluations were performed using the SOFA score for Group I and the SAPS II score for Group II from admission until the fifth day. The comparison was analysed using an independent t-test. Both the SOFA and SAPS II scales were efficient in forecasting the mortality of ICU-admitted patients. An independent t-test indicates that there was no statistically notable distinction between the SOFA and SAPS II in mortality prediction from the initial day (p=0.079) to the fifth day (p=0.062). The SOFA and SAPS II, the tools employed, exhibit no disparities in forecasting mortality rates among critically ill patients in the intensive care unit. Additionally, both methods are promising for predicting the mortality rate.

Keywords: *Critically Ill Patient, Intensive Care Unit, Mortality Rate, SAPS II, SOFA.*

Introduction

An intensive care unit (ICU), alternatively referred to as an intensive therapy unit (ITU) or critical care unit (CCU), is a specialised department within a hospital that is designed to provide intensive care to individuals grappling with severe and potentially life-threatening illnesses or injuries. There are several reasons for ICU admission, including severe respiratory failure, cardiovascular instability, neurological emergencies, major surgeries, severe trauma, burns, organ failure, sepsis, and more. The primary purpose of an ICU is to monitor and care for patients who require close and constant attention due to the critical nature of their medical conditions. In recent years, there has been a growing recognition of shifts in the population admitted to intensive care units [1]. Despite continuous monitoring and the provision of specialised care with advanced equipment, the mortality rate in ICUs remains high, often due to the severity of illnesses, comorbidities, timing of interventions, and other factors. It is reported that ICU mortality rates among the general population and patients with sepsis were 16.2% and 25.8%, respectively, as per the Intensive Care Over Nations audit report, which evaluated the global impact of critical illness [2]. A prospective cohort study investigated how compliance with resuscitation and management bundles affected mortality across 150 intensive care units from sixteen countries in Asia. The study revealed that blood culture, broad-spectrum antibiotics, and central nervous

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system involvement independently predicted mortality in 62.5%, 63.9%, and 39.7% of cases, respectively [3]. The International multicenter prevalence study on sepsis reported a global mortality rate of 28.4%, with Asia contributing 30.8% from 62 countries, involving 1794 patients [4]. Among mechanically ventilated patients, a mortality rate of 28% was observed [5]. The prediction of mortality in intensive care units is a critical aspect of healthcare in clinical practice. As medical advancements continue to enhance the positive outcomes of patient care, the ability to evaluate and anticipate the likelihood of mortality among critically ill patients becomes increasingly important. In the dynamic and complex environment of the ICU, where patients often present with severe and life-threatening conditions, promptly recognising those at elevated risk of mortality is paramount. Various scoring systems and predictive models have been developed and implemented to assist healthcare professionals in objectively evaluating the severity of illness and predicting patient outcomes. These models often incorporate a combination of physiological parameters, laboratory values, and clinical information to generate a quantitative evaluation of the patient's status. Among the well-established tools for mortality prediction in the ICU are the Sequential Organ Failure Assessment (SOFA) [7] and the Simplified Acute Physiology Score (SAPS II) [6]. The scores generated by these two tools provide clinicians with standardised methods for evaluating the severity of organ dysfunction and physiological derangement, respectively, allowing for a more comprehensive understanding of the patient's prognosis. Accurate mortality prediction not only aids in clinical decision-making but also facilitates resource allocation, enhances communication with patients and their families, and contributes to the overall quality of healthcare delivery in the ICU setting. The SOFA score finds extensive use in managing severe sepsis and can also be utilised for forecasting both the length of admission and the likelihood of mortality [8]. Certain studies suggest that while both the SAPS II and SOFA scores can forecast the outcome of septic shock, the SAPS II demonstrates slightly lower efficacy compared to the SOFA score. The latter provides a better reflection of the patient's circulatory system [9, 10]. Recognising a gap in assessing parameters for predicting mortality, the current study was conducted to compare the SAPS II and SOFA scores for predicting mortality.

Materials and Methods

Study Design and Setting

A non-experimental descriptive comparative research design was used to assess the predictive capability of SAPS II and SOFA scores in determining the mortality rate among patients admitted to the medical intensive care unit of Saveetha Medical College and Hospital in Chennai after obtaining formal permission from the hospital authority. Totally 78 samples were enrolled for the study, out of which 7 samples were excluded due to various reasons. The remaining 68 samples were chosen through a convenience sampling method, satisfying the inclusion criteria, and were divided into groups: group I (n = 34) and group II (n = 34). Four samples from each group were dropped out during the study period, and 30 samples in each group were considered for analysis.

Sample Size Calculation

The sample size was calculated using power analysis, assuming a 10% prediction in the mortality rate with a 30% standard deviation, 85% power, 5% significance level, and 10% dropout.

Selection Criteria

The inclusion criteria for sample selection were male and female patients aged over 21 years who spent over 24 hours in the ICU and were willing to participate in the study. Patients who died within 24 hours and those who had consented not to resuscitate or do not intubate were excluded from the study.

Outcome Measures

The tools used for gathering data encompassed background and clinical variables, SAPS II, and the SOFA score. The SOFA score consists of six parameters: PaO_2 (partial pressure of oxygen), Glasgow Coma Scale, cardiovascular system (mean arterial pressure), bilirubin level, creatinine, and coagulation profile. Each parameter is scored from 0 to 4, and the response given depends on the condition, with the interpreted mortality rate depending on the total score. The score was interpreted as follows: 0-6, indicating less than 10% mortality; 7-9, considered as 15-20%; 10-12, indicating 40–50%; 13–14, suggesting 50–60%; 15–80%; and a score greater than 15 considered as more than 90% mortality. SAPS II consists of a 15-item questionnaire that incorporates information about age, Glasgow Coma Scale, temperature, heart rate, systolic pressure, PaO2/FiO2 if on mechanical ventilator or CPAP, renal output in the last 24 hours, blood urea nitrogen or serum urea, sodium, potassium, bicarbonate, bilirubin, white blood cell count, chronic diseases, and types of admission. The score is interpreted as follows: if the score is less than 29, the mortality rate is 10%; for scores between 30 and 40, it is 35%; for scores between 41 and 52, it is 50%; for scores between 53 and 64, it is 75%; and a score of 65 or higher indicates a mortality rate of 90%. Both tools are highly valid and reliable for predicting mortality rates. Multiple-choice questionnaires were employed to gather the baseline information on demographic and clinical variables.

Procedure

Following the sample selection, the researchers introduced themselves, clarified the study's objectives in the native language of the participants, and responded to any questions or issues. Mortality rates were predicted by measuring the responses indicated in the SOFA score for Group I from day one until the fifth day of admission. The total time required for data collection for each patient was 5 minutes. Similarly, for Group II, SAPS II was used. Figure 1 shows the Consort flowchart of methodology.

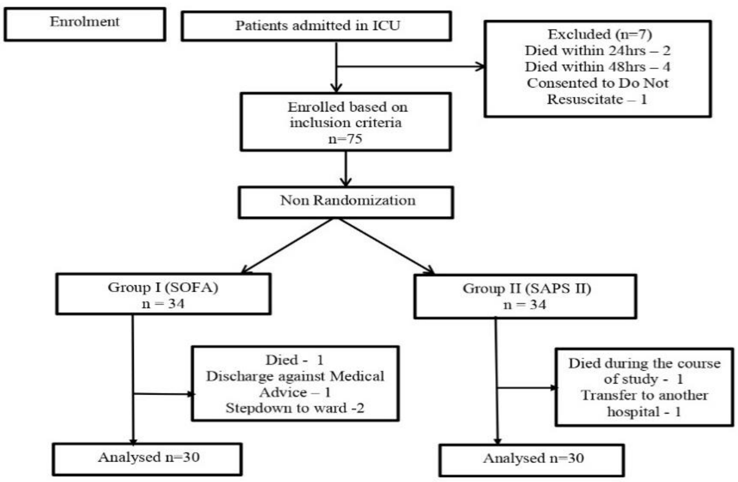

Figure 1. CONSORT Flowchart of Methodology

Ethical Consideration

The study was conducted after receiving ethical approval from the Institutional Ethical Committee of Health Sciences (896/2023/ISRB/SCON dated January 7, 2023) and formal permission from the hospital authority. Written consent was obtained that ensured confidentiality was maintained. Throughout the study, strict adherence to ethical principles ensured the maintenance of anonymity and confidentiality.

Statistical Analysis

The data were analysed using IBM SPSS version 22.0 software (IBM Corp., Armonk, NY, USA). Background information of the participants was described in terms of frequency and percentage. The scores were presented in frequency and percentage terms. Unpaired t-tests were utilised to compare mortality prediction levels between SOFA and SAPS II. The chi-square test was used to associate SOFA and SAPS II scores in predicting mortality with selected clinical and demographic variables. A probability value of $p<0.05$ was considered statistically significant.

Results

Background Information of Patients Admitted to the ICU

Table 1 shows that the mean age of the patients admitted to the ICU is 52±12 in Group I and 53±11 in Group II. The gender ratio and BMI of the patients in Groups I and II are 19:11 and 24:6, and 24.8±1.3 and 23.9±1.2, respectively.

Table 1. Background Information of Patients Admitted to the ICU

Demographic Variables	Group I (SOFA)	Group I (SAPS II)
Age in Years	52±12	53±11
Gender		
Male: Female	19:11	24:6
Dietary pattern		
Vegetarian: Non-vegetarian	18:12	14:16
Body Mass Index (BMI)	24.8±1.3	23.9±1.2

Values are presented as mean±standard deviation.

Clinical Variables of Patients Admitted to the ICU

As depicted in Table 2. most of the patients admitted in ICU, 13(43.3%) in SOFA and 1&(56.7%) in SAPS group had routine admission, 16(53.4%) in SOFA and 15(50%) in SAPS were admitted in MICU, 19(63.3%) in SOFA and 16(53.3%) in SAPS were admitted for 24 – 48 hrs, 15(50%) in SOFA and 19(63.3%) in SAPS had hypertension as comorbid illness, 17(56.7%) in SOFA and 18(60%) in SAPS were not given mechanical ventilator support, 15(50%) in SOFA and 19(63.3%) in SAPS group were fed through nasogastric tube.

Table 2. Clinical Variables of Patients Admitted to the ICU

Clinical Variables	Group I (SOFA)	Group I (SAPS II)
	Frequency (%)	**Frequency (%)**
Types of Admission		
Emergency admission	11 (36.7)	7 (23.3)
Routine admission	13 (43.3)	17(56.7)
Elective admission	4 (13.3)	3 (10)
Day case admission	2 (6.7)_	1 (3.3)
Observation admission	-	2(6.7)
Types of ICU		
MICU	16 (53.4)	15 (50)

Clinical Variables	Group I (SOFA)	Group I (SAPS II)
	Frequency (%)	Frequency (%)
RICU	12	12 (40)
SICU	1 (3.3)	-
CCU	1 (3.3)	3 (10)
Day of admission to the ICU		
Within 24 hrs of admission	11 (36.7)	14 (46.7)
24 – 48 hrs of admission	19 (63.3)	16 (53.3)
Co-morbidities		
DM	12 (40)	11 (36.7)
Hypertension	15 (50)	19 (63.3)
COPD	3 (10)	-
Mechanical Ventilator support		
Yes	13 (43.3)	12 (40)
No	17 (56.7)	18 (60)
Route of feeding		
Nasogastric tube	8 (26.7)	11 (36.7)
Oral feeding	15 (50)	19 (63.3)
Total parenteral nutrition	3 (10)	-
Nothing per oral	4 (13.3)	-

Values are presented as frequency and percentage.

Mortality Prediction using SOFA

Table 3 shows that on Day 1, three (10%) had both less than 10% and 50-60% mortality predictions, four (13.3%) had 15-20% mortality, 18 (60%) had 40-50% mortality, and 2 (6.7%) had more than 80% mortality prediction. On the other hand, on Day 5, 12 (40%) had less than 40% mortality, 13 (43.3%) had 15-20% mortality, and 5 (16.7%) had 40-50% mortality prediction.

Table 3. Mortality Prediction using SOFA

SOFA Score	<10% (0 – 6)		15 – 20% (7–9)		40 – 50% (10–12)		50 – 60% (13–14)		>80% (15)		>90% (16– 24)	
	F	%	F	%	F	%	F	%	F	%	F	%
Day 1	3	10.0	4	13.3	18	60.0	3	10	2	6.7	-	-
Day 2	4	13.3	5	16.7	16	53.3	4	13.3	1	3.3	-	-
Day 3	7	23.3	9	30.0	10	33.3	4	13.3	-	-	-	-
Day 4	10	33.3	6	20.0	8	26.7	6	20.0	-	-	-	-
Day 5	12	40.0	13	43.3	5	16.7	-	-	-	-	-	-

Values are presented as frequency and percentage.

Mortality Prediction using SAPS II

Table 4 shows that on Day 1, three (10%) had both 10% mortality predictions, five (16.7%) had 25% mortality, 17 (56.7%) had 50% mortality, and five (16.7%) had 75% mortality predictions. Conversely, on Day 5, 14(46.7%) had both 10% mortality predictions, 13(43.3%) had 25% mortality, and three (10%) had 75% mortality predictions.

Table 4. Mortality Prediction using SAPS II

SAPS II	10% (< 29)		25% (30-40)		50% (41-52)		75% (53-64)		90% (> 77)	
Score	**F**	**%**	**F**	**%**	**F**	**%**	**F**	**%**	**F**	**%**
Day 1	3	10.0	5	16.7	17	56.7	5	16.7	-	-
Day 2	4	13.3	6	20.0	14	46.7	6	20.0	1	3.3
Day 3	8	26.7	9	30.0	9	30.0	4	16.7	-	-
Day 4	10	33.3	8	26.7	9	30.0	3	10.0	-	-
Day 5	14	46.7	13	43.3	3	10.0	-	-	-	-

Values are presented as frequency and percentage.

Comparison of SOFA and SAPS Scores for Mortality Prediction

Table 5 shows that the mean SOFA scores of mortality prediction were compared with the mean score of SAPS II from the first day until the fifth day using an independent t-test. The calculated student independent "t" test value was not statistically significant at the $p<0.05$ level. This implies that there was no significant difference between the SOFA and SAPS II mortality prediction among the patients admitted to the ICU from the first day until the fifth day.

Table 5. Comparison of SOFA and SAPS Scores for Mortality Prediction

Day	SOFA Score		SAPS II Score		Independent "t" test
	Mean	**SD**	**Mean**	**SD**	
Day 1	19.4	3.12	57.6	2.62	t=1.789 p=0.079 N.S
Day 2	18.9	2.71	49.5	2.31	t=2.641 p=0.086 N.S
Day 3	18.6	2.52	40.2	2.14	t=1.647 p=0.091 N.S
Day 4	17.5	1.78	31.5	1.93	t=1.43 p=0.063 N.S
Day 5	12.4	1.24	23.2	1.71	t=1.381 p=0.062 N.S

N.S. – Not Significant

Association of Mortality Score with Selected Demographic Variables

SOFA and SAPS II mortality prediction scores had not shown a statistically significant association with demographic and clinical variables of patients admitted to the ICU at the level of $p<0.05$.

Discussion

Intensive care units are equipped with advanced equipment, supervised by experienced, skilled healthcare professionals, and designed to monitor and address critical organ failures that may occur during both chronic and acute illnesses [11]. In the ICU, mortality rates surpass those of other departments due to a variety of reasons. Typical factors that contribute to this include age, the underlying illness, and the seriousness of complications associated with the disease [12]. Furthermore, inflammatory markers such as albumin and C-reactive protein have been noted to be associated with mortality [13–15]. The random blood sugar and serum sodium levels were used as predictors of mortality among patients with acute stroke [16]. Similarly, gestational age, low birth weight, temperature, and entry hypertension were used to predict the infant mortality rate and demonstrated that logistic regression has a higher accuracy rate compared to the novel random forest method [17]. Forecasting the mortality of severely ill patients admitted to critical care units is essential for improving prognostic accuracy, refining treatment strategies, optimising resource utilisation, supporting clinical decision-making, promoting quality improvement, and contributing to the standardisation of critical care practices. Both SOFA and SAPS II scores are commonly utilised tools for evaluating the physiological status and vital organ function, thereby predicting the severity of illness and its outcomes among severely and acutely ill patients. Comparing the SAPS II and SOFA scores is crucial for understanding the strengths and limitations of each scoring system, which helps in tailoring treatment plans for these patients. The current study thoroughly evaluated and forecasted the mortality of patients admitted to the ICU. It found that both methods effectively predict mortality and revealed no significant distinction between the predictive capabilities of the SOFA and SAPS II scores. The findings of this study align with a study conducted by Dnyanesh N. Morkar et al., who compared APACHE II, SOFA, and SAPS II scores in ICU-admitted sepsis patients with organ dysfunction. Their study reported that all three scores exhibited a favourable prediction of mortality rate. Notably, the APACHE II score displayed higher sensitivity at 24 and 48 hours, while SAPS II exhibited higher specificity at the same intervals [18]. Nevertheless, it's crucial to highlight that the current study did not specifically target sepsis or organ failure; rather, it encompassed all ICU-admitted patients. In another retrospective analysis, the SOFA score was contrasted with the Acute Physiology and Chronic Health Evaluation II (APACHE II), demonstrating superior discrimination, calibration, and predictive capability for ICU mortality compared to SOFA. Notably, SOFA did not meet the anticipated outcomes among these measurement scales [19]. In a study conducted in a general ICU by Cissé-Luc Mbongo et al., SAPS III, APACHE II, and SOFA were evaluated for their ability to predict mortality. The results indicated that SAPS III exhibited outstanding discrimination and calibration when compared to APACHE II. SAPS III reliably forecasts the risk of mortality within the mixed adult ICU cases [20]. However, it is noteworthy that this study's findings strongly support the conclusions of the current study. Parikshit Singh et al. conducted a comparison to assess the predictive accuracy of mortality using APACHE III and SAPS II scores among patients with sepsis, severe sepsis, and septic shock admitted to the ICU. They found that APACHE III was a more reliable predictor of 28-day mortality compared to SAPS II, although the difference in mortality prediction margin was not significant [21]. Similarly, in an investigation led by Can Wang et al., it was proven that qSOFA (quick SOFA) demonstrated superior overall prognostic accuracy compared to the Systemic Inflammatory Response Syndrome (SIRS) criteria and the National Early Warning Score (NEWS) in predicting mortality among patients suspected of having sepsis [22]. Likewise, Karpagam et al., in their study to predict mortality among patients with acute pancreatitis using the RANSON and BISAP scores, found that the RANSON score had a higher accuracy in predicting mortality compared to the Bedside Index for Severity in Acute Pancreatitis (BISAP) score [23]. A study conducted by Shaoxin Yuan et al. aimed to evaluate the effectiveness of the Acute Physiology and Chronic Health Evaluation II (APACHE II) score, Poisoning Severity Score (PSS), and Sequential Organ Failure Assessment (SOFA) score combined with lactate in predicting mortality among emergency department patients suffering from organophosphorus poisoning. The study suggested that all three scoring systems could forecast the prognosis. However, the SOFA score emerged as the superior predictor due to its simplicity and objectivity, especially when lactate was included. Additionally, the SOFA score significantly improved the predictive capabilities compared to these three scoring systems [24]. According to the findings of the present study, in comparison with findings from similar studies, it indicates that the SOFA scale effectively predicts mortality among ICU patients, regardless of whether they have sepsis or not, and across all medical and surgical conditions that result in critical illness. The notable aspect of this study is its incorporation of patients with and without sepsis. Nevertheless, there are only a few studies that directly compare the SOFA score with SAPS II. More research is warranted to explore comparisons among SAPS, SAPS II, and SAPS III, as well as examinations of SOFA and qSOFA, along with APACHE II, in predicting mortality. This could help design management strategies to decrease mortality and provide top-tier care.

Conclusion

The findings of this study suggest that both SAPS II and SOFA, the tools employed, effectively predict mortality and show no difference in predicting mortality rates among critically ill patients in the intensive care unit. Furthermore, both approaches show promise in predicting mortality rates among such patients in the intensive care unit.

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Conflict of interest

The authors declare no conflict of interest.

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