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Comparative analysis of intensive care unit prognostication scores and their renal components in predicting hospital mortality among critically ill patients

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Abstract

Introduction: Prognostication is essential for risk stratification in the intensive care unit (ICU). The SOFA, APACHE II, and SAPS II scores are widely used severity scoring systems, although their renal components differ. Given the association of acute kidney injury (AKI) with higher morbidity and mortality, this study aimed to evaluate these scoring systems and identify which renal component best predicts ICU outcomes. Such an insight can enhance the precision of risk assessment in critically ill patients.

Methods: A retrospective observational cohort study was conducted involving all patients admitted to the ICU of Sultan Ahmad Shah Medical Centre (SASMEC@ICU). SOFA, APACHE II, and SAPS II scores, along with their individual components, were calculated within the first 24 hours of ICU admission.

Results: Of the 1,513 patients analysed, 360 (23.8%) died in hospital. The SOFA score had the highest predictive accuracy for hospital mortality with an AUC of

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0.78, followed by SAPS II (0.77) and APACHE II (0.72). Optimal cut-off points were identified for practical application. The renal components of the SOFA and SAPS II had similar AUCs of 0.64, while APACHE II's renal component was lower (0.62). Findings were consistent in the AKI subgroup.

Conclusions: The SOFA score outperformed APACHE II and SAPS II in predicting hospital mortality in critically ill patients. The renal components of the SOFA and SAPS II scores were more predictive than the that of APACHE, likely due to the inclusion of urine output criteria. Future multicentre studies using raw patient-level data are needed to develop a robust prognostic model tailored to our local ICU population.

Keywords: APACHE II score, intensive care unit, prognostication, SAPS II Score, SOFA Score

Introduction

Accurate prediction of outcomes in critically ill patients is essential for clinical decision-making, prognostication, and resource allocation in the intensive care unit (ICU).[1] Commonly used severity scoring systems include the Acute Physiology Chronic and Health Evaluation score (APACHE),[2] Simplified Acute Physiology Score (SAPS),[3] and the Sequential Organ Failure Assessment (SOFA).[4] These tools incorporate various physiological variables to estimate the severity of illness and risk of mortality.

These prognostic tools are frequently utilised to assist clinicians in estimating the probability of survival or the need for interventions. Both APACHE II and SAPS II scores include a range of physiological variables, and the SOFA score is designed to assess the severity of organ failure, including renal dysfunction. Despite their widespread use, there is ongoing debate about the accuracy of these scoring systems for predicting outcomes, particularly regarding mortality.

Acute kidney injury (AKI) is a common complication in ICU patients and is strongly associated with increased morbidity and mortality.[5] Consequently, renal function plays a central role in severity scoring. Each scoring system incorporates renal parameters differently: SAPS II uses blood urea nitrogen and urine output, APACHE II includes serum creatinine, while SOFA integrates both serum creatinine and urine output. The variations may influence the predictive performance of each score. This study aims to compare the predictive accuracy of the 3 commonly used scoring systems and to determine the best renal scores for predicting hospital

mortality in the ICU. The findings will offer insights into which renal score is most useful for clinical prognostication and decision-making.

Methods

This retrospective cohort observational study was conducted in the intensive care unit (ICU) of Sultan Ahmad Shah Medical Centre (SASMEC @IIUM). Ethical approval was obtained from the International Islamic University Malaysia Research Ethics (IREC 2021-304). All patients admitted to the ICU during the study period were screened for inclusion and exclusion criteria. Inclusion criteria included age above 18 years and ICU stay longer than 24 hours. Exclusion criteria included missing data. AKI was defined according to the Kidney Disease-Improving Global Outcomes (KDIGO) creatinine definition.

Data for ICU scoring systems (SOFA, APACHE II, and SAPS II), including their individual component scores, were routinely recorded and extracted from existing ICU records. Details of how the individual components were scored in APACHE II, SOFA, and SAPS are detailed in Appendix 1, with renal component scoring outlined specifically in Appendix 2.

Statistical analysis

All statistical analyses were performed using IBM SPSS Statistics version 26.0 (IBM Corp., Armonk, NY, USA). Continuous variables were presented as mean ± standard deviation (SD) for normally distributed data or median (interquartile range) for non-normally distributed data. Group comparisons were conducted using the independent t-test for normally distributed variables or the Mann-Whitney U test for non-parametric data. Categorical variables were compared using the chi-square test. A p-value < 0.05 was considered statistically significant.

The predictive performances of the scoring systems were evaluated using the area under the curve (AUC) of the receiver operating characteristic (ROC) curve of sensitivity versus 1-specificity. AUC values were interpreted as follows: 0.7–0.8 (acceptable), 0.8–0.9 (excellent), and > 0.9 (outstanding). Sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) were calculated for each score. The optimal cut-off values were determined using Youden's index**,** which identifies the point on the ROC curve that maximizes the difference between true positive and false positive rates.

A predefined subgroup analysis was conducted for patients diagnosed with AKI according to KDIGO creatinine criteria. The performance of the total and renal scores

in this subgroup was separately evaluated using ROC curve analysis to determine if predictive accuracy differed in this high-risk population.

The sample size for this study was not determined a priori but was based on available data from ICU admissions over the 6-year period from 2017 to 2021. Historical data indicate approximately 400 admissions per year, resulting in a total pool of 1,600 patients. This sample size was sufficient to detect a good discriminatory performance of AUC of more than 0.80 with 80% power at a 5% significance level.

Results

A total of 1,691 ICU admissions were recorded between 2017 to 2021; after excluding missing data, 1,513 admissions were analysed (Fig. 1). Among these, 360 patients (23.8%) died during hospitalisation, while 1,153 (76.2%) survived. Within the cohort, 741 patients (49.0%) had AKI within 7 days of ICU admission, of which 219 (14.5 %) were Stage 1, 47 (3.1%) Stage 2, and 475 (31.4%) Stage 3.

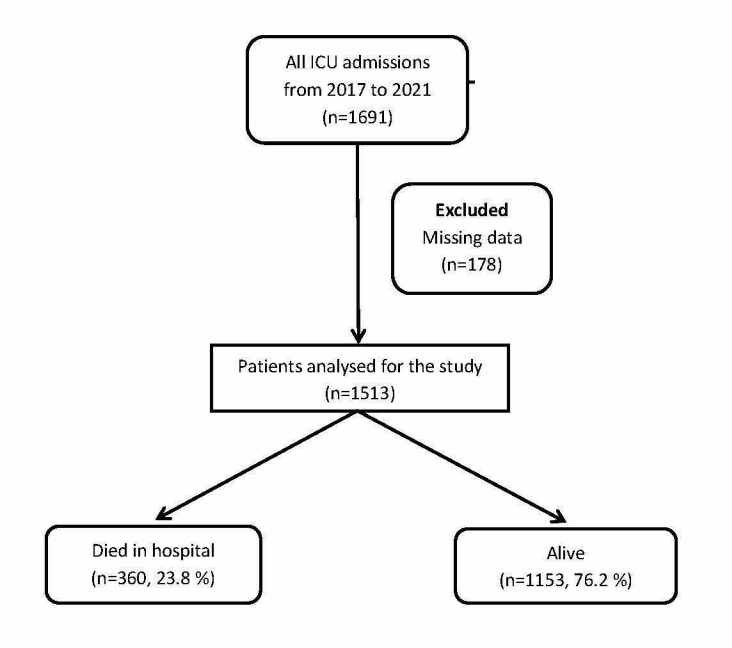

Fig. 1. Patient flow diagram.

Demographic and clinical characteristics

Table 1 shows the demographic and clinical characteristics of patients who died versus those who survived. Patients who died during hospitalisation were significantly older than those who survived (62.3 vs. 56.8 years, $p < 0.0001$). A greater proportion of deaths occurred among patients admitted under the medical category compared to the surgical group ($p < 0.0001$). The incidence of AKI was similar between those who died and those who survived (48.5% vs. 49.2%, $p = 0.82$), and there were no significant differences in AKI staging between the groups. However, patients who died had significantly higher peak serum creatinine levels within 7 days (304 vs. 194 µmol/L, $p < 0.0001$), indicating more severe renal dysfunction. Additionally, a significantly higher proportion of patients who died required mechanical ventilation (85.8% vs. 56.3%, $p < 0.0001$), reflecting greater severity of illness.

Table 1. Comparison of demographic and clinical profiles between survivors and non-survivors

Variables	All patients (*n* = 1513)	Died in hospital (*n* = 360)	Alive (*n* = 1153)	*p*-value
Age (years)	58.1 ± 15.2	62.3 ± 12.7	56.8 ± 15.7	< 0.0001
Gender (male)	836 (55.3)	199 (55.3)	637 (55.2	0.99
Category **Medical** **Surgical**	 797 (52.7) 715 (47.3)	 226 (62.8) 134 (37.2)	 571 (49.5) 581 (50.4)	< 0.0001
AKI by KDIGO creatinine criteria	741 (49.0%)	174 (48.5%)	567 (49.2%)	0.82
AKI Stages **Stage I** **Stage II** **Stage III**	 219 (14.5%) 47 (3.1%) 475 (31.4)	 48 (13.4%) 10 (2.8%) 359 (31.1)	 171 (14.8%) 37 (3.2%) 116 (32.3)	0.87
Baseline creatinine (µmol/l)	140 ± 161	175 ± 278	150 ± 182	0.55
Maximum creatinine within 7 days (µmol/l)	220 ± 241	304 ± 233	194 ± 238	< 0.0001
Mechanical ventilation, n (%)	958 (63.3)	309 (85.8%)	649 (56.3%)	< 0.0001

Data expressed as mean ± SD, n (%), or median (lower quartile – upper quartile). AKI: Acute Kidney Injury; KDIGO: Kidney Disease-Improving Global Outcomes; APACHE II: Acute Physiology and Chronic Health Evaluation II Score; SOFA: Sequential Organ Failure Assessment

The total scores of APACHE II, SAPS II and SOFA scores were higher in those who died compared to those who survived (Table 2). Among the components of APACHE II score, patients who died had significantly worse values in cardiovascular parameters (mean arterial pressure and heart rate), biochemical markers (pH, sodium, potassium, creatinine, haematocrit, white cell count, and bicarbonate), as well as higher scores for age and chronic health status ($p < 0.0001$ for all). Similarly, all 6 organ-specific components of the SOFA score, respiratory, haematology, hepatic, cardiovascular, central nervous system, and renal, were markedly elevated in those who died compared to survivors ($p < 0.0001$). In the SAPS II score, all components showed significantly higher values among non-survivors, except for temperature and chronic disease, which did not differ significantly between groups ($p = 0.11$ and $p = 0.73$, respectively). These findings reflect a consistent pattern of more severe physiological derangements and organ dysfunction among patients who did not survive.

Table 2. Comparison of APACHE II, SOFA, and SAPS II Scores and Their Individual Components Subscores by Hospital Survival Outcome

Variables	**All patients (*n* = 1513)**	**Died in hospital (*n* = 360)**	**Alive (*n* = 1153)**	***p*-value**
APACHE II Score	14.89 ± 7.30	18.89 ± 6.72	13.48 ± 6.99	< 0.0001
Temperature	0.08 ± 0.36	0.08 ± 0.30	0.08 ± 0.38	0.92
Mean arterial pressure	0.38 ± 0.86	0.60 ± 1.04	0.32 ± 0.78	< 0.0001
Heart rate	0.65 ± 1.00	0.84 ± 1.08	0.59 ± 0.97	< 0.0001
Respiratory rate	0.27 ± 0.66	0.32 ± 0.73	0.26 ± 0.63	0.14
Oxygenation	0.90 ± 1.28	1.03 ± 1.33	0.86 ± 1.27	0.02
ph	0.95 ± 1.33	1.43 ± 1.50	0.79 ± 1.23	< 0.0001
Sodium	0.29 ± 0.75	0.43 ± 0.85	0.25 ± 0.71	< 0.0001
Potassium	0.29 ± 0.71	0.42 ± 0.90	0.25 ± 0.63	< 0.0001
Creatinine	1.46 ± 1.64	2.03 ± 1.69	1.28 ± 1.58	< 0.0001
Haematocrit	0.79 ± 1.14	1.07 ± 1.31	0.71 ± 1.07	< 0.0001
White cell count	0.66 ± 0.94	0.88 ± 1.06	0.59 ± 0.89	< 0.0001
Bicarbonate	1.59 ± 1.55	2.15 ± 1.63	1.42 ± 1.48	< 0.0001
Glasgow Coma Scale	3.07 ± 4.86	4.26 ± 4.96	2.72 ± 4.78	0.03

Variables	All patients (*n* = 1513)	Died in hospital (*n* = 360)	Alive (*n* = 1153)	*p*-value
Age	3.18 ± 2.00	3.68 ± 1.84	3.02 ± 2.02	< 0.0001
Chronic health	3.18 ± 2.23	3.65 ± 2.17	3.02 ± 2.24	< 0.0001
SOFA Score	4.83 ± 3.67	7.76 ± 3.87	3.92 ± 3.09	< 0.0001
Respiratory	1.18 ± 1.21	1.49 ± 1.27	1.08 ± 1.17	< 0.0001
Haematology	0.37 ± 0.82	0.61 ± 0.98	0.29 ± 0.76	< 0.0001
Hepatic	0.51 ± 0.92	0.85 ± 1.15	0.41 ± 0.80	< 0.0001
Cardiovascular	1.07 ± 1.61	1.98 ± 1.82	0.78 ± 1.42	< 0.0001
Central nervous system	0.55 ± 1.21	1.12 ± 1.61	0.38 ± 1.00	< 0.0001
Renal	1.11 ± 1.45	1.64 ± 1.51	0.94 ± 1.38	< 0.0001
SAPS II Score	32.1 ± 16.5	34.2 ± 16.9	31.2 ± 16.2	< 0.0001
Age	9.45 ± 5.35	10.94 ± 4.59	8.98 ± 5.48	< 0.0001
Heart rate	0.78 ± 1.55	1.17 ± 1.84	0.65 ± 1.43	< 0.0001
Systolic blood pressure	0.53 ± 1.79	1.03 ± 2.47	0.37 ± 1.48	< 0.0001
Temperature	0.06 ± 0.47	0.09 ± 0.59	0.05 ± 0.43	0.11
PF ratio	6.33 ± 1.85	6.63 ± 1.87	6.22 ± 1.82	0.002
Urine output	3.09 ± 4.18	5.00 ± 4.78	2.49 ± 3.78	< 0.0001
Urea	2.66 ± 3.43	4.11 ± 3.55	2.20 ± 3.26	< 0.0001
White cell count	0.67 ± 1.51	0.95 ± 1.78	0.58 ± 1.40	< 0.0001
Potassium	0.45 ± 1.08	0.67 ± 1.26	0.39 ± 1.01	< 0.0001
Sodium	0.25 ± 1.01	0.47 ± 1.35	0.19 ± 0.87	< 0.0001
Bicarbonate	1.69 ± 2.16	2.56 ± 2.39	1.42 ± 1.99	< 0.0001
Bilirubin	0.41 ± 1.84	0.95 ± 2.83	0.24 ± 1.34	< 0.0001
Glasgow Coma Scale	2.25 ± 6.45	4.58 ± 8.99	1.53 ± 5.23	< 0.0001
Chronic disease	7.73 ± 4.50	7.86 ± 4.26	6.01 ± 1.73	0.73
Type of admission	5.29 ± 2.60	6.01 ± 1.73	5.06 ± 2.78	< 0.0001

Predictive performance of APACHE II, SOFA and SAPS II for hospital mortality

The predictive performance of APACHE II, SOFA, and SAPS II scores for hospital mortality is shown in Table 3 and Figure 2A. Among the 3, the SOFA score demonstrated the highest discriminatory ability (AUC = 0.78), followed closely by the SAPS II score (AUC = 0.77), and the APACHE II score, which had the lowest AUC at 0.72. Using Youden's index, the optimal cut-off points for predicting hospital mortality were 14.5 for APACHE II, 5.5 for SOFA, and 33.5 for SAPS II. These cut-off values reflect the best trade-off between sensitivity and specificity and may serve as practical thresholds for identifying critically ill patients at higher risk of in-hospital death.

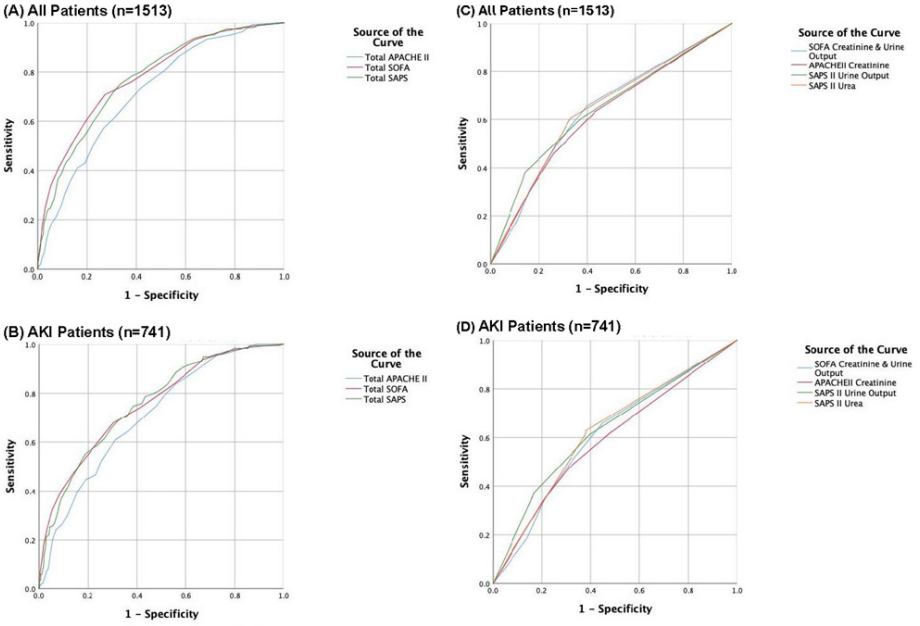

Fig. 2. Receiver operating characteristic (ROC) curves showing the predictive performance of the total scores of APACHE II, SOFA, and SAPS II in all ICU patients *(A)* and in patients with AKI *(B)*. *(C)* and *(D)* illustrate the performance of the renal components of the scoring systems, APACHE II creatinine, SOFA creatinine and urine output, SAPS II urea, and SAPS II urine output—for all patients and AKI patients, respectively.

Table 3. Predictive accuracy of APACHE II, SOFA, and SAPS II scores for hospital mortality

Scoring systems	AUC (95% CI)	*p*	Optimal cut-off point	Sensitivity (95% CI)	Specificity (95% CI)	PPV (95% CI)	NPV (95% CI)
APACHE II	0.72 (0.69–0.75)	< 0.0001	14.5	73.3 (68.8–77.9)	58.4 (55.5 - 61.2)	35.5 (32.0–38.9)	87.5 (85.2 -89.9)
SOFA	0.78 (0.75–0.81)	< 0.0001	5.5	70.8 (66.1–75.5)	72.8 (70.2–75.3)	44.8 (40.7–48.9)	88.9 (86.9% to 90.9)
SAPS II	0.77 (0.75–0.80)	< 0.0001	33.5	69.7 (64.9–74.5)	70.8 (68.2–73.5)	42.8 (38.8–46.8)	88.2 (86.1 - 90.3)

AUC: area under the curve; PPV: positive predictive values; NPV: negative predictive value

Table 4. Predictive accuracy of renal components from APACHE II, SOFA, and SAPS II scores for hospital mortality

Renal components	AUC (95% CI)	*p*	Optimal cut-off point	Sensitivity (95% CI)	Specificity (95% CI)	PPV (95% CI)	NPV (95% CI)
APACHE II renal score	0.62 (0.59–0.65)	< 0.0001	0.5	63.3 (58.4–68.3)	56.7 (53.8–59.6)	31.4 (28.0–34.7)	83.2 (80.6–85.8)
SOFA renal score	0.64 (0.61–0.67)	< 0.0001	0.5	65.6 (60.7–70.5)	60.2 (57.4–63.1)	34.0 (30.5–37.5)	84.8 (82.4–87.3)
SAPS II urea	0.64 (0.61–0.67)	< 0.0001	1.5	60.8 (55.8–65.9)	66.8 (64.1–69.6)	36.6 (32.7–40.4)	84.5 (82.1–86.8)
SAPS II urine output	0.64 (0.61–0.67)	< 0.0001	5	38.3 (33.2–43.3)	85.7 (83.7–87.7)	45.5 (39.9–51.1)	81.7 (79.5–83.8)

AUC: area under the curve; PPV: positive predictive values; NPV: negative predictive value

Predictive performance of the renal components of APACHE II, SOFA and SAPS II for hospital mortality

Table 4 and Figure 2C compare the predictive performance of renal components derived from APACHE II, SOFA, and SAPS II scores. Among them, the SOFA renal score demonstrated the highest discriminatory power (AUC = 0.64)**,** followed closely by the SAPS II urea score and urine output score (both AUC = 0.64), and the APACHE II renal component (AUC = 0.62). Although all showed statistically significant association with mortality ($p < 0.0001$), their predictive performances were modest.

The optimal cut-off points for the renal components are interpreted as follows: an APACHE II renal score of 0.5 corresponds to creatinine levels between 140 and 150 µmol/L; a SOFA renal score of 0.5 corresponds to creatinine levels between 110 and 170 µmol/L. For SAPS II, a renal score of 1.5 reflects urea levels between 10 and 29.6 mmol/L, while a score of 0.5 corresponds to urine output between 500 and 1000 mL per day.

Subset analysis in patients with AKI

A subset analysis among patients with AKI (n = 741) showed consistent findings. The SOFA score demonstrated the highest predictive accuracy for hospital mortality with an AUC of 0.75, followed closely by the SAPS II score, also with an AUC of 0.75, and the APACHE II score with an AUC of 0.71.

Similarly, the renal components of each scoring system showed modest predictive performance in this subgroup. The SOFA renal score had an AUC of 0.64, the SAPS II urea and urine output components both had AUCs of 0.64, and the APACHE II renal score had an AUC of 0.62. These results reinforce the consistency of the main findings in patients with AKI (Figs. 2B and 2C).

Discussion

The study evaluated the predictive accuracy of renal components in 3 widely used ICU severity scoring systems, SOFA, APACHE II, and SAPS II, for hospital mortality in critically ill patients. Among them, the SOFA score demonstrated the highest overall predictive performance (AUC 0.78), followed by SAPS II (AUC 0.77) and APACHE II (AUC 0.72). The renal components of SOFA and SAPS II scores showed better discrimination (AUC of 0.64 for both) compared to the renal component of APACHE II (AUC of 0.62).

The SOFA score is widely used for assessment of organ dysfunction and failure,[6,7] yet its utility in predicting mortality compared to the existing outcome scores has not been as extensively documented.[8–10] This study demonstrated that the SOFA scores outperformed both APACHE II and SAPS II in predicting hospital mortality. This is consistent with other studies that showed the predictive utility of SOFA score for mortality in general ICU patients,[11] patients with sepsis,[12] severe acute pancreatitis,[13] cardiovascular disease[14] and haematological malignancies.[15] The SOFA score has been shown to be associated with the prediction of 1-year mortality in 120 general ICU patients in our local setting.[8] In patients with AKI, the SOFA score has been shown to predict mortality, outperforming other severity scores. In a study of 836 patients with AKI on renal replacement therapy, SOFA demonstrated superior

predictive performance compared to APACHE II.[16] Similarly, in 189 AKI patients, the SOFA score achieved an AUC 0.908 (95% CI 0.866 to 0.950) for in-hospital mortality, the highest among the four scoring systems evaluated.[17]

The renal components of the SOFA, SAPS II, and APACHE II differ in their criteria. The renal SOFA score incorporates both serum creatinine and urine output, while renal SAPS II uses blood urea nitrogen and urine output, and renal APACHE II relies solely on serum creatinine (Appendix 2). The KDIGO guideline[18] recommends the use of both creatinine and urine output for AKI diagnosis. However, urine output is often difficult to measure, leading many studies to rely solely on creatinine criteria. Additionally, the urine output-based definition of AKI may be overly sensitive, potentially leading to overestimation of AKI cases.[19] Nevertheless, our results indicate that the renal components of the SOFA and SAPS II scores were more predictive of hospital mortality than the renal component of the APACHE II score. Both renal scores of SOFA and SAPS II incorporate urine output as the criteria. This finding is consistent with previous studies suggesting that incorporating multiple renal parameters, such as urine output and serum creatinine, may improve the predictive accuracy of these scoring systems.[20]

The identification of optimal cut-off points for APACHE II (14.5), SOFA (5.5), and SAPS II (33.5) enhances their clinical utility in ICU mortality prediction. These thresholds differ from those reported in a study of patients with acute respiratory distress syndrome in Vietnam, which showed SOFA > 9.5 and APACHE II > 19.5 as predictive of higher mortality.[21] This highlights the importance of local data due to variations in demographics, disease severity, and disease class. Defining setting-specific thresholds allows for more tailored risk stratification to the local population. Similarly, identifying renal component cut-offs offers additional prognostic value, though precise thresholds require future studies with raw patient-level data.

While this study primarily focused on the renal domain, other organ-specific components, such as cardiovascular, respiratory, hepatic, coagulation, and neurological functions, may also influence mortality prediction. Though not analysed individually in this study, future research could explore the relative prognostic contribution of each organ domain within these scoring systems.

Limitations of the study

Our study has several limitations. First, it was conducted in a single centre, which may limit the generalizability of the findings to different patient populations and clinical practices. Second, the retrospective design may introduce biases related to data completeness and patient selection, potentially affecting the reliability of the results. Third, we were unable to compare AKI defined by the KDIGO criteria with the renal components of the 3 scoring systems, as hourly urine output was not routinely

captured in our ICU. Future studies should address this gap to better validate the renal components of these scoring systems. Fourth, given the dynamic clinical status of ICU patients, reliance on a single time-point assessments may be suboptimal. Future studies should explore the prognostic value of serial scoring over time. Finally, we were only able to perform discrimination analysis using AUC, as access was limited to the total and domain-level scores of APACHE II, SOFA, and SAPS II. The lack of raw data restricted our ability to evaluate model calibration, a limitation that should be addressed in future research.

Conclusion

This study demonstrated the superior predictive performance of the SOFA score for hospital mortality in critically ill patients, outperforming both APACHE II and SAPS II. The renal components of SOFA and SAPS II were more predictive than that of APACHE II, likely due to their incorporation of urine output criteria in addition to biochemical parameters. Future multicentre studies using raw patient-level data should develop robust, locally tailored prognostic models by integrating demographic, biochemical, and physiological trends through machine learning

Declarations

Ethics approval and consent to participate and publish
Ethical approval was obtained from the International Islamic University Malaysia Research Ethics (IREC 2021-304). As the data obtained were from database, waiver of consent has been sought and approved by the ethics committee. Consent for publication was approved by SASMEC@IIUM.

Competing interests
Dr. Md Ralib and Dr. Mat Nor serve as editorial board members of Malaysian Journal of Anaesthesiology. Neither were involved in any part of the editorial process prior to publication.

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Appendix 1. APACHE II, SAPS II, and SOFA Scores

Acute physiologic assessment and chronic health evaluation (APACHE) II score

Reproduced from Wong and Knaus.[2]

A. Physiologic variables points

PHYSIOLOGIC VARIABLE	HIGH ABNORMAL RANGE					LOW ABNORMAL RANGE				PT SCORE
	4	3	2	1	0	1	2	3	4	
Temperature - rectal (°C)	> 41	39-40.9		38.5-38.9	36-38.4	34-35.9	32-33.9	30-31.9	< 29.9	
MAP (mmHg)	> 160	130-159	110-129		70-109		50-69		< 49	
Heart Rate	> 180	140-179	110-139		70-109		55-69	40-54	< 39	
Respiratory Rate (non-ventilated or ventilated)	> 50	35-49		25-34	12-24	10-11	6-9		< 5	
Oxygenation: [A-aDO$_2$ = (FiO$_2$ x 710) – (PCO$_2$ x 1.25) – PO$_2$]					FiO$_2$ = PCO$_2$ = PO$_2$ =					
a. FiO$_2$ > 0.5 record A-aDO$_2$	> 500	350-499	200-349		< 200					
b. FiO$_2$ < 0.5 record only PaO$_2$					PO$_2$ > 70	PO$_2$ 61-70		PO$_2$ 55-60	PO$_2$ < 55	
Arterial pH	> 7.7	7.6-7.69		7.5-7.59	7.33-7.49		7.25-7.32	7.15-7.24	< 7.15	
Serum Na (mmol/L)	> 180	160-179	155-159	150-154	130-149		120-129	111-119	< 110	
Serum K (mmol/L)	> 7	6-6.9		5.5-5.9	3.5-5.4	3-3.4	2.5-2.9		< 2.5	
Serum Creatinine (umol/L)	> 305	170-304	130-169		53-129		<53			
Hematocrit (%)	> 60		50-59.9	46-49.9	30-45.9		20-29.9		< 20	
WBC (total/mm^3)	> 40		20-39.9	15-19.9	3-14.9		1-2.9		< 1	
Glasgow Coma Score (GCS)	Score = 15 minus actual GCS (see below)									
Serum HCO$_3$ (venous mmol/L) - not preferred, use if no ABG's	> 52	41-51.9		32-40.9	22-31.9		18-21.9	15-17.0	< 15	
									ACUTE PHYSIOLOGY SCORE (APS): Sum of the 12 individual variable points =	

B. Age Points - Assign points to age as follows:

AGE (yrs)	POINTS
<44	0
45-54	2
55-64	3
65-74	5
>75	6
AGE SCORE=	

C. Chronic Health Points - If the patient has a history of severe organ system insufficiency (see below) or is immunocompromised assign points as follows:

a. For nonoperative or emergency postoperative pt -- 5 points
b. For elective postoperative pt -- 2 points

CHRONIC HEALTH SCORE =

D. APACHE II SCORE - Sum of A + B + C

CHRONIC HEALTH DEFINITIONS

Organ insufficiency or immuno-compromised state evident prior to this hospital admission and are consistent with the following criteria:

A. APS points	
B. Age points	
C. Chronic Health points	
APACHE II SCORE =	

LIVER: Biospy-proven cirrhosis and documented portal hypertension; prior episodes of upper GI bleeding attributed to portal hypertension; or prior episodes of hepatic failure/encephalopathy/coma

CARDIOVASCULAR: New York Heart Association Class IV

RESPIRATORY: Chronic restrictive, obstructive, or vascular disease resulting in severe exercise restriction (*i.e.*, unable to climb stairs or perform activities of daily living or household duties; or documented chronic hypoxia, hypercapnia, secondary polycythemia, severe pulmonary hypertension (>40 mmHg), or ventilator dependency

RENAL: Receiving chronic dialysis

IMMUNO-COMPROMISED: The patient has received therapy that suppresses resistance to infection (*i.e.*, immuno- suppressive treatment, chemotherapy, radiation, long term or recent high dose steroids, or has a disease that is sufficiently advanced to suppress resistance to infection (*i.e.*, leukemia, lymphoma, AIDS)

GLASCOW COMA SCALE		
Parameter	**Response**	**Points Assigned (please circle)**
Eyes Open	Spontaneously	4
	On spoken command	3
	On pain	2
	No response	1
Best Motor Response	To spoken command	6
	To painful stimulus:	
	Localized pain	5
	Flexion withdrawal	4
	Flexion abnormal	3
	Extension	2
	No response	1
Best Verbal Response	(Not on ventilator)	
	Oriented & converses	5
	Disoriented & converses	4
	Inappropriate words	3
	Incomprehensible sounds	2
	No response	1
	(On ventilator)	
	Appears oriented	5
	Questionably oriented	3
	Generally unresponsive	1
	Total GCS =	

Simplified acute physiology (SAPS) II score

Reproduced from Le Gall.[3]

Points variable	26	13	12	11	9	7	6	5	4	3	2	0	1	2	3	4	6	7	8	9	10	12	15	16	17	18
Age In years												<40						40-59				60-69	70-74	75-79		≥80
Heart rate Beats per minute				<40							40-69	70-119				120-159		≥160								
Systolic BP mmHg		<70						70-99				100-199		≥200												
Body temperature												<39			≥39											
Only if ventilated or Continuous Positive Airway Preassure PaO_2/FiO_2				<100	100-199		≥200																			
Urinary output Litre per day				<0.5					0.5-0.999			≥1.0														
Serum urea mmol/l												<10.0					10-29.9				≥30.0					
WBC $10^3/mm^3$			<1.0									1.0-19.9			≥20											
Serum potassium mmol/l										<3.0		3.0-4.9			≥5.0											
Serum sodium mmol/l								<125				125-144	≥145													
Serum bicarbonate mmol/l							<15			15-19		≥20														
Bilirubin umol/l												<68.4				68.4-102.5				≥102.6						
Glasgow Coma Scale	<6	6-8				9-10		11-13				14-15														
Chronic disease																				Met. cancer	Haema malign				AIDS	
Type of admission												Elective surgery					Medical		Emergency surgery							
Sum of points																										

Total SAPS II score: _____ Points_____ Risk of Hospital Death %

Sequential organ failure assessment (SOFA) score

Reproduced from Vincent *et al.*[4]

SOFA Score	0	1	2	3	4
Respiration PaO_2/FiO_2	>400	<400	<300	101–200 with respiratory support	0 –100 with respiratory support
Haematological Platelets$x10^3$ per mm^3	>150	101 - 150	51 - 100	21 - 50	0 - 20
Hepatic Bilirubin umol/l	0 - 19	20 - 32	33 - 101	102 - 204	>204
Cardiovascular Hypotension *Inotrope/ vasopressor ≥ 1 hour	MAP > 70 mmHg	MAP <70mmHg	Dopamine 1-5µg/kg/min or Dobutamine any dose	Dopamine 6-15 µg/kg/min or Adrenaline ≤0.1 µg/kg/min or Noradrenaline ≤0.1 µg/kg/min	Dopamine >15 µg/kg/min or Adrenaline >0.1 µg/kg/min or Noradrenaline >0.1 µg/kg/min
Central Nervous System Glasgow Coma Score	15	13 - 14	10 - 12	6 - 9	3 - 5
Renal Creatinine umol/l or Urine output ml/ day	0 - 110-	110 - 170-	171 - 299-	300 - 440 or 200 - 499	>440 or < 200
TOTAL					

*Adrenergic agents administered for at least 1 hour

TOTAL SOFA SCORE:

Appendix 2

Table 1. Renal components of APACHE II, SAPS II and SOFA scores

Scoring system	Variables	Components	Score
Renal SOFA	Creatinine and urine output	Creatinine ≥ 440 µmol/l or urine output < 200 ml/day	+4
		Creatinine 300– 400 µmol/l or urine output < 500 ml/day	+3
		Creatinine 171–299 µmol/l	+4
		Creatinine 110–170 µmol/l	+1
		Creatinine < 110 µmol/l	0
Renal SAPS II	Urine output	Urine output < 500 ml/day	+11
		Urine output 500 to 999 ml/day	+4
		Urine output ≥ 1000 ml/day	0
Renal SAPS II	Urea	Urea ≥ 30 mmol/l	+10
		Urea 10–29.6 mmol/l	+6
		Urea < 10 mmol/l	0
Renal APACHE II	Creatinine	Creatinine ≥ 350 µmol/l	+4
		Creatinine 200–340 µmol/l	+3
		Creatinine 150– 90 µmol/l	+2
		Creatinine 60–140 µmol/l	0
		Creatinine < 60 µmol/l	+2