The comparison score of SPEEDS, MEDS, SOFA, APACHE II, and SAPS II as predictor of sepsis mortality: A Systematic Review

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**ABSTRACT**
We performed the comparison of characteristics and values under the curve, including Sepsis Patient Evaluation Emergency Department Score (SPEEDS), Mortality in Emergency Department Sepsis (MEDS), Sequential Organ Failure Assessment (SOFA), Acute Physiology and Chronic Health Evaluation II (APACHE II), and Simplified Acute Physiology Score (SAPS II). We searched PubMed, Science direct, ProQuest, and EBSCO for identify full-text English-language papers published between 2012-2022. We discovered that each of the five-scoring lead to mortality forecasts in sepsis patients. MEDS predicted mortality in sepsis patients better than SAPS II after 28 days but the SPEEDS was more accurate than MEDS. The SOFA score predicts mortality better than the APACHE II. APACHE II has lesser validity than SAPS II. The AUC SOFA scores have greater in diagnosing sepsis patients’ mortality than other scores. However, they are overstated, inefficient, and non-cost-effective, making SOFA scoring unfavourable in enhancing healthcare quality.

Introduction

Sepsis is a condition effected by chronic inflammation in the body as a result of a simple infection. Sepsis is actually the body’s "wrong response" when fighting infecting microorganisms (Coelho & Martins, 2012). In a study, it was said that usually, 50% of sepsis cases originate from infections in the lungs (Elbaih et al., 2019). According to available data, sepsis cases in the United States (US) range around 76 over 100 per 100,000 individuals. According to some research, the mortality rate with sepsis can range from 30% up to 60%. This sepsis instance is particularly concerning because the occurrence and fatality rate of sepsis is increasing year after year. It was recently revealed that the death rate was increasing by 9% every year. In addition, hospital mortality due to 25% sepsis was in the worldwide (regardless of age), 31% in Asia, Africa, South America,
and 24% in North America, Europe, Australia/New Zealand (Chen et al., 2017). From the data, it can be said that the case of death due to sepsis is a serious case and requires attention so that it does not increase again every year.

In the case of sepsis, a simple assessment system for detecting the risk of patients’ mortality will be a great help. A basic assessment can aid in clinical settings to identify unhealthy patients and guide treatment decisions, in research settings to undertake risk-adjusted assessments, and in administration to monitor resource expenditure, analyse, and increase quality (Shapiro et al., 2003). Mortality due to sepsis can be assessed through several measurement systems such as Sepsis Patient Evaluation Emergency Department Score (SPEEDS), Mortality in Emergency Department Sepsis (MEDS), Sequential Organ Failure Assessment (SOFA), Acute Physiology and Chronic Health Evaluation II (APACHE II), Simplified Acute Physiology Score (SAPS II), etc. Each system assesses anomalies based on clinical findings, laboratory results, or treatment interventions.

As a reason, the goal of this review is to contrast the MEDS, SOFA, APACHE II, SAPS II, and SPEEDS scores for indicating mortality rate in patients with sepsis. This study is considered important because the cases of sepsis that cause deaths are getting more serious and almost increasing every year. Then from several previous studies, there has not been found an article that specifically discusses the comparison of scores of SPEEDS, MEDS, APACHE II, SAPS II, and SOFA as predictors of sepsis mortality. So, the author wants to know more about how the five scores compare. An alternative hypothesis (H1) in writing this review is that there is a comparison of scoring using MEDS, SPEEDS, APACHE II, SAPS II, and SOFA for indicating mortality in patients with sepsis.

Research Methods
Selected studies
Publication describing randomized control trial, observational, and meta-analysis of the comparison of SPEEDS, MEDS, SOFA Score, APACHE II, and SAPS II were sought by searching the following database: PubMed, EBSCO, ProQuest, Science Direct during 2013-2022. The search strategies for PubMed based on the terms recommended ‘(Comparison*)’ AND ‘(SPEEDS* OR SPEED* OR Sepsis Patient Evaluation in the Emergency Department Score*)’ AND ‘(MEDS* OR Mortality in Emergency Department Sepsis Score*)’ AND ‘(SOFA* OR SOFA Score* AND Sequential Organ Failure Assessment*)’ AND ‘(APACHE-II* OR Acute Physiology and Chronic Health Evaluation II*)’ AND ‘(SAPS II* OR Simplified Acute Physiology Score*)’. The study was conducted in English only. We found related studies first by title, then by abstract, and finally by full text. The authors of the two highlighted papers were contacted in order to obtain further information and unpublished works that were critical to the research.

Data extraction and outcome measures
One reviewer read the titles and abstracts on-screen. One reviewer separately gathered and reviewed potentially relevant papers for inclusion. Disagreement was settled by discussion.
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Results and Discussions

![Data Extraction Chart]

**Figure 1 Data Extraction Chart**

After the final screening full text, we found 21 studies included in the review. Seventeen studies applied cohort retrospectives and prospective as the methodology. Fourth other studies used meta-analysis, cross-sectional prospective, time-periodic, and observational research. The last screening showed 54 irrelevant subjects, 41 irrelevant interventions, 3 non-English articles, and 22 irrelevant results.

**Comparison of SPEEDS, MEDS, SOFA, APACHE II, and SAPS II in Predicting Mortality in Patients with Infection.** (See table 1)

A high specificity value for SOFA shows that SOFA is beneficial for identifying infected individuals who are at risk of deteriorating their illness. SOFA outperformed other scores, including Halm criteria, Quick Sequential Organ Failure Assessment (qSOFA), the infectious diseases society of America (IDSA)/American Thoracic Society,
Confusion, Urea, Respiratory Rate, Blood Pressure and Age Above or Below 65 Years (CURB-65), Confusion, Respiratory Rate, Blood Pressure and Age Above or Below 65 Year (CRB-65), and Systemic Inflammatory Response Syndrome (SIRS) with result of AUC score 0.948 (Ahnert et al., 2019). In the four studies mentioned above, SOFA outperformed qSOFA and SIRS, with an AUC of 0.75 which showed significantly outperforming other scores. Therefore, SOFA can be used as consideration for further examination of the condition of organ dysfunction in infected patients, starting to improve appropriate therapy, and as a consideration for referring patients to the intensive care room. However, low SOFA sensitivity values can mean subjects who are actually at high risk of aggravation or mortality can go unidentified appropriately (Seymour et al., 2016).

Prior research reported a statistically significant relation between death and declining mental status (p= 0.013), chronic infection (p= 0.005), and septic shock (p= 0.01). The research was conducted by Shapiro et al, discovered a strong relationship (p < 0.001) involving the mortality and the occurrence of septic shock, severe illnesses, and bad mental status. For MEDS criteria there were no significant differences that identified between the two groups. MEDS necessitates a subjective evaluation of the chance of short-term mortality and may perform less accurately as the condition progresses (Jones et al., 2008). MEDS had a combined sensitivity of 79% (95% CI 72% to 84%), and a specificity of 74% (68% to 80%) (G. Zhang et al., 2020).

The research conducted by (Shankar et al., 2022) stated the AUROC 0.895 (95% CI: 0.838-0.951) for PIRO and 0.857 (95% CI: 0.793-0.92) for MEDS, where the AUROC MEDS value is less than PIRO. Elbaih further stated that when applied to the entire sample group, the SPEEDS score was better than the MEDS score, with the AUC being 0.87 (95% CI 0.788-0.963) compared with 0.75 (95% CI 0.634-0.876) for MEDS. However, (Hermans et al., 2012) found that ROC CRP value 0.68 (CI 95% 0.58-0.78) was not better than the MEDS score 0.81 (95% CI 0.73-0.88) for estimating 28 days of hospital mortality.

Then, in prior investigations, the SPEED score parameter discovered a relation between hypotension and mortality (p= 0.048). Elbaih et al also added that an area under the curve was 0.87. In estimating 28-day mortality among patients with sepsis SPEED score was more informative and accurate than the MEDS (0.788-0.963). According to Shankar et al, revealed that SPEED score reached AUC 0.899 (95% CI: 0.847-0.951) in indicating mortality.

Another study found that the AUROC for MEDS were 0.857 (95% CI: 0.793-0.92) and predisposition insult response and organ failure (PIRO) scores 0.895 (95% CI: 0.838-0.951). As a result, the SPEED score parameter provides a dependable and quick technique for indicating mortality patients with sepsis (Bewersdorf et al., 2017).

In logistic regression analysis, the SPEED score is a strong predictor of 28-day death. As a result, SPEED score is an easier and faster prediction measurement that can be helpful employed to ensure that emergency department's restricted resources are allocated appropriately to high-risk patients. Previous observational study supported that the SPEED score can predict mortality in sepsis patients and it is easier tools to calculate.

Furthermore, the SOFA assessment system is currently used in various intensive care rooms in continental Europe and America. SOFA outperformed other measures in correctly detecting the severity of sickness in the initial day of admission to the hospital. (Liu et al., 2019)(X.-M. Zhang et al., 2020). AUC SOFA reached 0.880 that mean SOFA have the optimal accuracy for predicting hospital mortality, followed by Sepsis in Obstetric Symptom (SOS) (0.878), Modified Early Warning System (MEWS) (0.858),
qSOFA (0.847) and National Early Warning System (NEWS) (0.833) (Khwannimit et al., 2019). SOFA has the highest significant power to predict mortality in hospitals (AUROC, 0.76; 95% CI, 0.69-0.79) (Pairattanakorn et al., 2021). According to Garbero et al. SOFA has significant sensitivity to forecast the patient's status, and ≥2 scores are connected with a poor prognosis (de Freitas Garbero et al., 2019). In predicting mortality in the ICU, AUC SOFA reached up to 0.838 (95% CI 0.820-0.855) that means SOFA is the best prognosis capacity (Songsangjinda & Khwannimit, 2020). However, the SOFA score system has weaknesses that are in line with improving the quality of health management, thus the two assessment systems above are overestimating and less efficient and not cost-effective in predicting mortality (Andrias, 2016).

According to Juneja's findings, there was no meaningful improvement between APACHE II and SAPS II, despite the fact that APACHE II's AUROC curve (0.880) was bigger than SAPS II's (0.849). SAPS II had a superior calibration (2 = 6.073; P = 0.639) than APACHE II (Juneja et al., 2011). According to Ledoux et al., AUROC APACHE II reached 0.823 was significantly lower than AUROC SAPS II 0.850, and while APACHE II calibration (P = 0.037) appeared inadequate, SAPS II calibration (P = 0.671) performed rather well. Based on the studies presented above, it is possible to infer that SAPS II has greater validity than APACHE II (Ledoux et al., 2008).

Previous research by (Sun et al., 2017) also found cut-off values for SOFA, APACHE IV, and SAPS II of 6.5 points, 28.5 points, and 23.5 respectively with higher sensitivity and specificity with a percentage of each (78.2% & 94.4%), (83.6% & 90%). (87.3% & 89.6%). AUC for SOFA reached 0.920, 0.93 for APACHE IV, and 0.942, for SAPS II scores. Besides this, if the SAPS II score's sensitivity and specificity reach 100% and the specificity reach 38.0% and sensitivity reach 61.8% that indicated AUC SAPS II is higher when compared to the SOFA and APACHE IV score. This overestimation is partly explained by modification in the connection between some scores and mortality variables, most notably the heart rate, Glasgow Coma Score, and the diagnosis of AIDS for SAPS II.

For comparison, (Ozaydin et al., 2017) also gave the opinion that the ROC value for SAPS II was lower than the MEDS value with scores of 0.70 (0.62-0.78) and 0.76 (0.69-0.82) respectively with indications of SAPS II being a predictor of mortality with low effectiveness compared to MEDS.

**DISCUSSION**

Different classification methods will certainly give different results in assessing sepsis. Numerous research examined approaches for identifying ICU’s and emergency department’s patients who are at high risk of infection.

**Sepsis Patient Evaluation in the Emergency Department (SPEED)**

In this discussion, SPEEDS can be utilized to measure the risk of death in septic patients, designed specifically for adult patients. Furthermore, another assessment technique known as SPEED assesses the existence of immunosuppressive conditions such as HIV/AIDS, cancer, organ transplant patients, or the present use of immunosuppressive medicines, hypothermia (body temperature<36.0°C), hypoxemia (pulse oximetry<90%), hypotension (systolic pressure <90 mmHg), diabetes, low haematocrit (haematocrit<0.38), acidosis (blood pH<7.35), high lactate (blood lactate>2.4 mmol/L, and pneumonia. Even the SPEEDS score is thought to be easier than the MEDS because it is based entirely on the most basic and readily existing screening testing. According to the study, SPEEDS performed better than MEDS scores when distributed to the target sample population, with a higher AUC. Speed score can predict
85.7% at a score of >10. Previous studies found that patients with SPEED scores of 4-6 had 2.7 times the risk of accuracy 95% confidence interval (CI) of 1.5-5.0], and patients had SPEED scores of 7-9 had a 5.2 times risk (95% CI 2.9-9.2), and patients with SPEED scores of more than 10 had an 8.6-fold promote the risk of death (95% CI 4.9-14.7) compare to subjects using SPEED scores of 0-3.

**Mortality in Emergency Department Sepsis Score (MEDS)**

MEDS is the most extensively used and widely validated scoring system for indicating the mortality of sepsis patients in the emergency department. Another viewpoint was that MEDS represents the only score established particularly for the classification of sepsis patients hospitalizing to emergency department (Innocenti et al., 2018). The MEDS score also represents the most often examined model, with enrolment in its derivation cohort based on the clinical decision to take blood culture. The MEDS score has a shortcoming in that significant weight is provided to the attending physician's subjective evaluation of short-term mortality. MEDS scores are intended to predict mortality in sepsis emergency patients. MEDS mortality risk predictions are viewed by score category; the score of ≤4 has a very low risk (very-low risk), a score of 5-7 has a low risk (low risk), a score of 8-12 has a moderate risk (moderate risk), a score of 13-15 has a high risk (high risk), and a score of >15 has a very high risk (very high risk). The study of Hermans et al. showed the percentage of mortality risk of each MEDS score category as follows, in the score category ≤4 points the percentage of mortality reached 3.1%, for a score of 5-7 reached 5.3%, a score of 8-12 reached 17.3%, for the category of scores of 13-15 reached 40.0%, and a high-risk mortality category with a score of >15 reached 77.8% and AUC score of 0.81 (95% CI 0.73-0.88) [trend test: p<0.001].

**Sequential Organ Failure Assessment (SOFA)**

Furthermore, is SOFA score that was recently developed to indicate adult suspected infection patients who are at high risk of worsening outcomes. SOFA scores also reveal predictive information on past medical problems and sepsis severity indices based on multivariate study. SOFA ratings are based exclusively on physiological and laboratory features, and do not take into account host factors such as ethnicity, age, and comorbidities, which are important predictors of death in sepsis (Macdonald et al., 2014). SOFA and MEDS scores, which use medical and laboratory data to measure the severity of organ failure, have been shown to relate the mortality in sepsis patients treated in the emergency department.

SOFA scores represent simple and objective scores that allow calculating the total and severity of organ dysfunction. The third international consensus definition for sepsis and septic shock introduces updated the definitions of sepsis and criteria. Due to the inadequate specificity and sensitivity, the earlier identification of SIRS and sepsis were substituted with a recent sepsis definition, which was identify as potentially fatal organ malfunction by the host's aberrant reaction to infection. Although SOFA ratings were originally developed to measure organ failure rather than forecast mortality, the correlation between organ dysfunction and death showed to have a strong correlation in multiple investigations (Ferreira et al., 2001) (Haydar et al., 2017). The most significant variables in calculating SOFA scores are oxygenation and breathing support. Throughout the length of stay in the ICU, many critically sick patients require extensive ventilation support (ICU). In addition, renal damage is a key component of the SOFA score. SOFA score parameters consist of parameters for assessing cardiovascular (mean arterial pressure [MAP]), system coagulation (platelets), liver (bilirubin), respiration (PaO2/FiO2), renal (serum keratin), and central nervous system (Glasgow coma scale
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SOFa’s score cut-off score was 6.5 sensitivity 73.33% and specificity 84.38% (CI 95%, 0.86-0.98) with SOFA score indication >7 connecting with high risk of mortality (21/21; 52.38%) compared to lower SOFA score (4/58; 6.89%) (Nunez Lopez et al., 2017).

**Acute Physiology and Chronic Health Evaluation (APACHE II)**

APACHE II is an analytical method for measuring symptom severity in chronically ill patients based on past medical history, age, and several physiological measurements that might aid in decision-making for hospital resource distribution, therapy evaluation, and patient prognosis. In COVID-19 patients, Cheng et al. found that the overall APACHE II score was a good predictor of disease severity and mortality than CURB-65 and MuLBSTA (multi-lobular infiltration, hypolimphosytosis, bacterial co-infection, having smoked history, hypertension, and maturity level).

APACHE Score II was first created by Knaus et al. in 1985 using three scoring components; acute physiological score (APS), the most significant component was determined from 12 clinical parameters collected within the initial 24 hours of treatment (Omer & Zaghla, 2019). The APS component for APACHE II scores is calculated using the most abnormal measurement outcomes. If there is an unmeasured variable then it is considered to have a value of 0. The APACHE II score system itself also has a number of limitations due to selection bias, lead time bias, and the difficulty of choosing the main diagnosis that causes patients to enter the ICU. The cut-off score of APACHE II was 17.5 with 66.67% sensitivity and 81.25% specificity (CI 95%, 0.74-0.92) with indications that subjects with APACHE II scores ≤9 reduced the mortality rates compared to subjects with APACHE II scores of 10-19 (12.22%) and subjects with APACHE scores >20 (43.75%) (p<0.01) (Sakr et al., 2008).

**Simplified Acute Physiology Score (SAPS II)**

In 1993 SAPS II was launched as a development of the previous generation SAPS. This system is the first system to use statistical modelling techniques. Now the SAPS III score system has been developed which is used in many countries in Europe. SAPS II is a popular disease severity classification method. All of these scores are risk stratification techniques used in clinical settings to estimate the probability of death. SAPS II scores are determined using an online calculator based on the worst test results and clinical symptoms reported with in the initial 24 hours following ICU hospitalization (Yaşar et al., 2017). SAPS II contain 17 parameters, including maturity level, physiological factors (pulse rate, blood pressure, urine volume, temperature, PaO2/FiO ratio 2, White Blood Cells (WBC), Blood Urea Nitrogen (BUN), bicarbonate ions (HCO3), K, Na, bilirubin, Glasgow coma scale score (GCS), and chronic illnesses (AIDS, haematological malignancy, metastatic cancer) (Yu et al., 2017) (Hollinger et al., 2018). The SAPS II cut-off score is 23.5 with 87.3% sensitivity and 89.6% specificity. The SAPS II score has an AUC of 0.942. Likewise, if the SAPS II score's sensitivity and specificity both reach 100%, 38.0% specificity and 61.8% sensitivity are increased. So, if the SAPS II score is >24 it is possible for the patient to have a higher risk of death.

**Characteristics of Assessment Variables in Each Assessment Tools**

Table 2 describes the criteria for assessment variables from SPEEDS, MEDS, SOFA, APACHE II, SAPS II. The SPEEDS system evaluates the occurrence of immunosuppressive diseases such as HIV/AIDS, cancers, low haematocrit (haematocrit 0.38), hypoxemia (pulse oximetry90%), organ donor recipients, or recent use of immunosuppressant therapy, hypotension (systolic pressure90 mmHg), acidosis (blood pH<7.35), hypothermia (body temperature36.0°C), increased lactate (blood lactate>2.4
mmol/L, and pneumonia. The MEDS Score System determines whether a patient does have a fatal illness (<30 days life expectancy), trouble breathing or hypoxia, septic shock, platelets <150,000/mm3, maturity level > 65 years, lower respiratory tract infections, home care residents, and changes in mental status. Furthermore, this SOFA Scoring system has 6 variables, namely the variable PaO2 / FiO2, platelets, bilirubin, GCS, and serum creatinine, besides that it also measures cardiovascular from the presence or absence of hypotension (Fauziyah, 2020) (Fröhlich et al., 2016). (see table 2)

Then there are the 12 parameters of APACHE II scoring, which are pulse rate temperature, mean arterial pressure (MAP), Glasgow coma score (GCS), respiratory rate, oxygenation, serum sodium, serum potassium, haematocrit, white blood cell count, blood pH or serum HCO3, and serum creatinine (Knaus et al., 1985). In addition, it is also influenced by age and chronic disease scores. The SAPS II evaluation system includes 17 variables, including 12 physiological parameters, maturity level, entrance groups (internal medicine, elective surgery, and emergency surgery), and three central disorders (acquired immunodeficiency syndrome, leukaemia, metastasis). All assessment criteria calculate clinical physiological variables and laboratory results. SPEEDS and SAPS II have criteria that assess immune abnormalities in patients. SPEEDS also measures the condition of low oxygen in the blood or hypoxemia. Meanwhile, MEDS has assessment criteria for terminal diseases and hypoxia. Then SOFA and APACHE II have criteria for assessing cardiovascular conditions with MAP and both measure Glasgow Coma Score. Lactic serum assessment conducted on SPEEDS supporting the criteria for a "one hour bundle" sepsis campaign in the emergency resuscitation room.

**Conclusion**

Based on the 5 scorings that we present; we find that each of them has criteria and objectives that later lead to mortality predictions in sepsis patients. MEDS scores were better than SAPS II in predicted mortality of sepsis patients after 28 days. Whereas the SPEEDS Score is more accurately used to predict mortality in sepsis patients after 28 days of treatment than MEDS scoring. SOFA score mortality prediction is more significant than APACHE II scoring. While the validity of APACHE II is lower than SAPS II. SOFA scores significantly had higher AUC scores than other scores in estimating mortality in sepsis patients, but overestimated and less efficient and not cost effectively caused SOFA score advantages in terms of improving the quality of health services to underdogs.

**References**


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Songsangjinda, T., & Khwannimit, B. (2020). Comparison of severity score models based on different sepsis definitions to predict in-hospital mortality among sepsis patients.
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