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**Original Article**

# Comparison of Mortality Prediction, of APACHE II, SAPS II and SOFA ICU Scoring Systems in Patients with Severe Sepsis and Septic Shock in ICU of A Tertiary Care Hospital

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**Abstract**
*Severe sepsis accounts for one in five admissions to intensive care units (ICUs) and is the leading cause of death in the noncoronary ICU. Unfortunately, the outcome of sepsis has remained unacceptably high to the tune of 30%–40% despite the development and availability of an increasing array of higher-generation antibiotics with broader spectrum of coverage and advances in intensive supportive measures. Mortality Prediction Systems have been introduced as tools for assessing the performance of ICUs. They help in individual patient outcome prediction by reducing uncertainty and provide an opportunity for improved decision making.*
**Aims and Objectives:** *To assess the mortality of patients with sepsis and septic shock and to prognosticate the patients by using defined scores like SAPS II, APACHE II and SOFA scores.*
**Materials and Methods:** *This observational study included 120 patients with severe sepsis and septic shock and Acute Physiologic Assessment and Chronic Health Evaluation II (APACHE II) and Simplified Acute Physiological Score II (SAPS II) and Sequential Organ Failure Assessment (SOFA) indices were calculated at baseline to assess the severity of illness.*
**Results:** *In this study the maximum number of patients were from the age groups 40 to 50 years (46 patients) and 60 to 80 years (45 years). Out of 120 patients 43 patients did not survive. Male to female distribution in this study noted was 49 and 71patients respectively. Respiratory and urosepsis was noted in 45% and 30% respectively. Among 120 patients, 35 patients had an increasing SOFA trend, out of which 34 did not survive ($p<0.05$). In this study it was observed that the SAPS II had the highest sensitivity (0.721) and APACHE II scoring had the highest specificity (0.766). When comparing individually all the three scoring systems were significant ($p<0.05$) in predicting the mortality, but SAPS II had the most area under the ROC curve (p value 0.047) with odds ratio of 1.449.*
**Conclusion:** *Individually, all the three scoring systems can be used to detect the outcome of the patient with sepsis and severe sepsis.*
**Keywords:** *APACHEE II scoring system, SAPS II scoring system, SOFA scoring system, Sepsis.*

## Introduction

Sepsis is life threatening organ dysfunction caused by a deregulated host response to infection[(1)] and is one of the leading causes of in-hospital mortality and morbidity among medical and surgical patients. In addition to the high mortality associated with severe sepsis and septic shock, it also results in significant morbidity and financial burden. Based on previous data it has been predicted that the incidence of severe sepsis will increase at a rate of 1.5 % per year, leading to more than a million episodes of severe sepsis annually in the United states by 2020.[(2)]. Although well recognized as an important health issue globally, most of the epidemiological data regarding the incidence and mortality of sepsis have emerged from western countries and puts the overall incidence of sepsis ranging from 10% to 30% with mortality ranging from 10% to 56%. Available data from India suggest that the overall mortality of all septic patients is approximately 14% and that of severe sepsis alone is higher than 50%.

There is a lack of an agreed severity of illness scoring system for patients with sepsis. In the absence of such a system, it is difficult to interpret sepsis outcome. Mortality Prediction Systems have been introduced as tools for assessing the performance of ICUs. Prognostic scoring systems have a number of applications. They help in individual patient outcome prediction by reducing uncertainty and provide an opportunity for improved decision making. Prognostic scoring systems can facilitate quality assessment of an individual ICU by allowing comparison of its overall performance to a large scale representative database.

The 3 commonly used scoring systems are Acute Physiology and Chronic Health Evaluation (APACHE), and Simplified Acute Physiology Score (SAPS) and Sequential Organ Function Assessment (SOFA). The present study attempts to use APACHE-II, SAPS-II and SOFA scoring systems to assess the Predictive Mortality in patients of severe sepsis and septic shock and to compare these scores to see which is a better predictor of mortality in an ICU of a tertiary care hospital.

## Materials and Methods

The current study is a prospective observational study between February 2016 to April 2017. 120 patients with severe sepsis and septic shock admitted in ICU in our institution were included in the study. Patients were included in the study after meeting the diagnostic criteria for severe sepsis and septic shock during the first 24 hours of admission.

1. Severe Sepsis-Sepsis with one or more signs of organ dysfunction.
   a. Cardio-vascular system-Systolic Blood Pressure (SBP) of less than or equal to 90 mm Hg that responds to administration of intravenous fluids.
   b. Renal-Urine output less than 0.5 ml/kg/hour for one hour despite adequate fluid replacement.
   c. Respiratory system-PaO2/FiO2 ratio below 250.
   d. Metabolic-pH less than 7.3 or a plasma lactate level more than 1.5 times of the upper limit of normal value.
   e. Hematologic system-Platelet count below 80,000/mm3.
2. Septic Shock- Sepsis with hypotension (SBP less than 90 mm Hg) for at least one hour despite adequate fluid resuscitation or the need for vasopressors to maintain SBP greater than 90 mm Hg.

Detailed clinical, and laboratory data were recorded, including arterial blood gas analysis and relevant cultures of blood, urine, sputum, tracheal aspirates, or other samples as indicated. Acute Physiologic Assessment and Chronic Health Evaluation II (APACHE II) and Simplified Acute Physiological Score II (SAPS II) and Sequential Organ Failure Assessment (SOFA) indices were calculated at baseline to assess the severity of illness. The total duration of ICU stay, details mechanical ventilation were also recorded.

**Results**

This study included 120 patients between the age group of 19 to 89 years and it was observed that 46 patients and 45 patients were from age group 40 to 59 years and 60 to 80 years respectively. This study included 71 females and 49 male patients and out of 71 female patients 27 patients died and out of 49 male patients 16 patients had died. Respiratory sepsis was the commonest aetiology noted in 54 patients followed by urosepsis which was noted in 36 patients. Other aetiologies noted were GI sepsis (11 patients), meningitis (7 patients) and others (12 patients). Amongst patients with respiratory sepsis 21 patients did not survive. 15 patients and 3 patients did not survive with urosepsis and GI sepsis respectively. Out of 120 patients in this study 83 patients has septic shock and 37 patients were without septic shock. Among 120 patients, 43 patients who did not survive 38 patients were in septic shock.

**Table 1-** Analysis of co morbidities of patients admitted with severe sepsis and septic shock in ICU

| Total 120 | DM 64 | HTN 34 | CVA 7 | CLD 7 | COPD 22 | CAD 18 | CKD 29 |
|---|---|---|---|---|---|---|---|
| Survived 77 | 41<br>53.2% | 20<br>26% | 3<br>3.9% | 4<br>5.2% | 12<br>15.6% | 11<br>14.3% | 13<br>16.9% |
| Did not survive 43 | 23<br>53.5% | 14<br>29% | 4<br>9.3% | 3<br>7% | 10<br>23.3% | 7<br>16.3% | 16<br>37.2% |
| Significance | $\chi^2$=0.001<br>P=1.00 | $\chi^2$=0.589<br>P>0.05 | $\chi^2$=1.468<br>P>0.05 | $\chi^2$=0.159<br>P>0.05 | $\chi^2$=1.085<br>df=1<br>P>0.05 | $\chi^2$=0.086<br>df=1<br>P>0.05 | $\chi^2$=6.220<br>df=1<br>P<0.05 |

This study showed that, among 120 patient's 64 patients had DM, followed by 34 patients with HTN, 29 patients had CKD, and 22 patients had COPD.

In this study it was observed that out of 120 patients, 62 patients required ventilator support and out of 43 patients who did not survive, 39 (90.7 %) patients were provided with ventilator support. p value of 0.001 (significant).

**Table 2 –** Analysis of Severe sepsis and septic shock by APACHE II, SAPS II and SOFA scoring system and its outcome on patients admitted in ICU

| Total 120 | APACHE II<br>Mean ± SD | SAPS II<br>Mean ± SD | SOFA (day 1)<br>Mean ± SD |
|---|---|---|---|
| Survived 77 | 17 ± 7.2 | 45.7 ± 14.2 | 8.1 ± 3.6 |
| Did not survive 43 | 25.5 ± 9.1 | 65.3 ± 19.5 | 11.6 ± 4.2 |
| Difference between means | 8.5 | 19.6 | 3.5 |
| Significance | T=5.628<br>P<0.001 | T=6.324<br>P<0.001 | T=4.726<br>P<0.001 |

The above table shows the mean scores of the three scoring system and its significance on the outcome of patients. The table also depicts that, when calculating individually, all the three scoring system are significant in predicting the mortality of the patients.

**Table 3 –** Analysis of SOFA score trend in patients admitted in ICU with severe sepsis and septic shock.

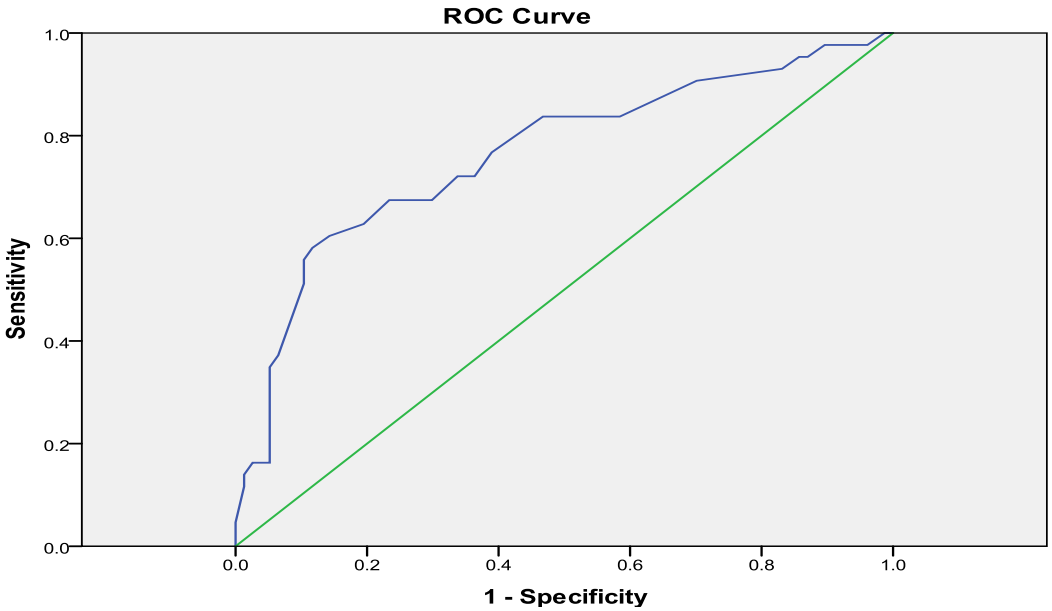
| Total 120 | Increasing 35 | Static 25 | Decreasing | Significance |
|---|---|---|---|---|
| Survived 77 | 1<br>1.3% | 19<br>24.7% | 57<br>74% | $\chi^2$=83.085<br>df=2<br>P<0.001 |
| Did not survive 43 | 34<br>79% | 6<br>14% | 3<br>7.0% | |

The above table shows that the increasing SOFA score trend is significantly associated with poor outcomes. Among the total 120 patients, 35 had an increasing SOFA trend, out of which 34 did not survive.

**Prediction of Mortality Cut Off Points**

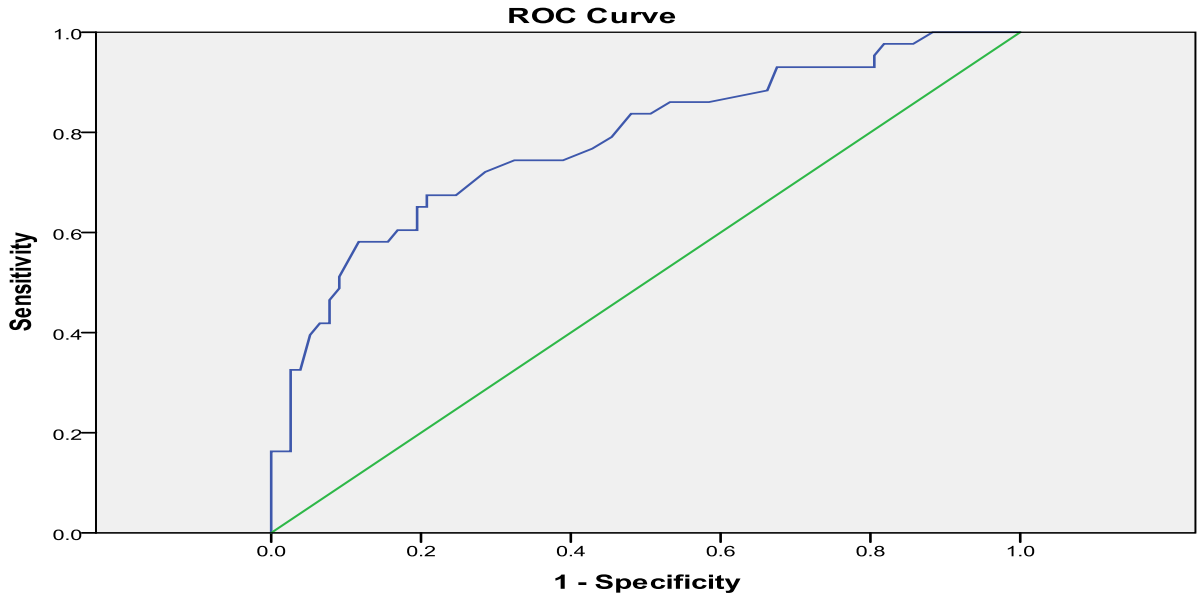
The three scoring system was applied to all 120 sepsis patients. The cutoff point to predict mortality was calculated by plotting the ROC curve.

Figure 1 - ROC curve for APACHE II scoring system



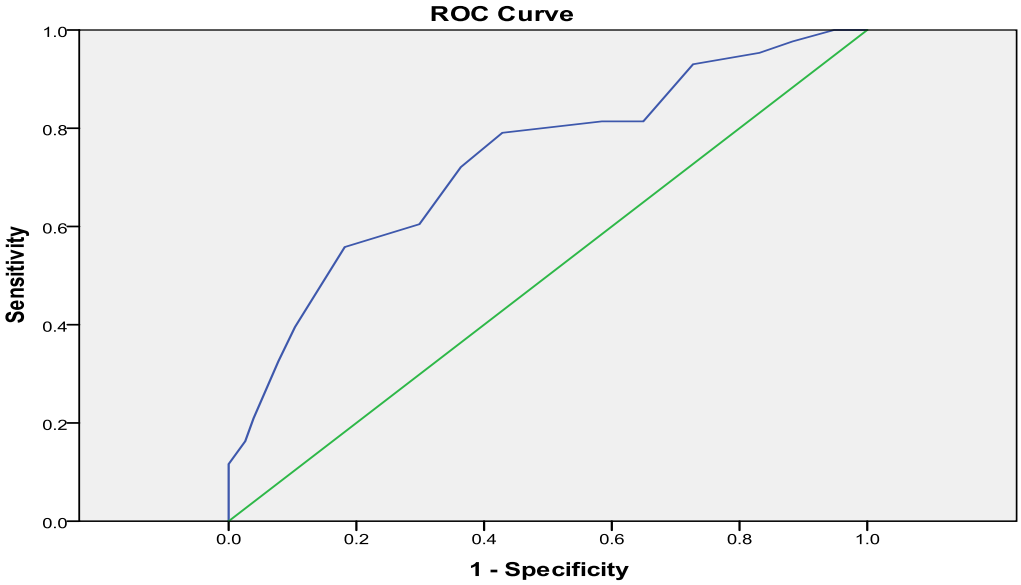

The cut-off point for APACHE II was taken as 21.5 and mortality above this value was considered in calculating the best out of 3 scoring systems.

**Figure 2 –** ROC curve for SAPS II scoring system




The cut-off point for predicting mortality by SAPS II was taken as 51.5. Mortality falling above this cu-toff was taken for comparing the 3 scoring systems.

**Figure 3 –** ROC curve for SOFA scoring system




The cut off point for SOFA was taken as 10.5 for predicting the mortality and to compare the 3 scoring systems in predicting the mortality of the patients.

**Table 4 –** Area under ROC curve of APACHE II, SAPS II and SOFA scoring system

| Scores | Area | Std error | Significance | 95% confidence interval | |
|---|---|---|---|---|---|
| | | | | Lower bound | Upper bound |
| APACHE II | 0.764 | 0.048 | P <0.001 | 0.670 | 0.858 |
| SAPS II | 0.782 | 0.045 | P <0.001 | 0.693 | 0.871 |
| SOFA | 0.733 | 0.049 | P <0.001 | 0.638 | 0.828 |

The above table shows that the area under curve for each scoring system with SAPS II having the maximum area of 0.782

**Table 5** – Sensitivity and specificity of APACHE II, SAPS II and SOFA scoring system

| Score | Cut off points | Sensitivity (Did not survive) | Specificity (Survived) | Difference | LR (+) | LR (-) |
|---|---|---|---|---|---|---|
| APACHE II | 21.5 | 0.674 | 0.766 | 0.092 | 2.90 | 0.423 |
| SAPS II | 51.5 | 0.721 | 0.714 | 0.007 | 2.52 | 0.390 |
| SOFA | 10.5 | 0.605 | 0.701 | 0.096 | 2.02 | 0.563 |

The above table shows that the SAPS II has the highest sensitivity and APACHE II scoring has the highest specificity.

**Table 6 –** Logistic regression equation of APACHE II, SAPS II and SOFA scoring system

| Scores | B | S.E | WALD | DF | Sig | Odds Ratio |
|---|---|---|---|---|---|---|
| APACHE II | .035 | .042 | 0.700 | 1 | 0.403 | 1.036 |
| SAPS II | .048 | .024 | 3.953 | 1 | 0.047 | 1.449 |
| SOFA | .034 | .078 | 0.191 | 1 | 0.662 | 1.035 |

When comparing individually, all the 3 scores were significant (p <0.05) in predicting the mortality of the patients, but SAPS II has the most area under the ROC curve (p value 0.047) with odds ratio of 1.449.

**Discussion**

**Analysis of Patient Outcome based on age Distribution and Gender**

The majority of patients in our study were in the age group 40 to 59 years (46 patients) and 60 to

80 years (45 patients). And mean age of patients in this study who did not survive was 58 ± 15.3. In a study conducted in Yale-New Haven Hospital ICU by Theresa Rowe, Katy L.B. Araujo, Peter H. Van Ness, Margaret A. Pisani and and Manisha Juthani Metha showed that the diagnosis of sepsis in older adults upon ICU admission was associated with an increase in mortality compared with those admitted without sepsis. They conducted a prospective cohort study of 309 participants ≥60 years admitted to an ICU, 196 (63%) met the definition of sepsis. Among those admitted with and without sepsis, 75 (38%) vs 20 (18%) died within 1 month of ICU admission (P < .001) and 117 (60%) vs 48 (42%) died within 1 year (P < .001)[3]. The study showed that there was no significance between outcome of patients among male and female patients as p value was >0.05. Similar studies done in Weill medical college of Cornell university by Sounmitra R. Eachempati, MD, Lynn Hydro, RN, Philip S. Barie in ICU subjects showed no difference in outcome between male and female patients. Patients had mean ± SE age of 67±1 years. There was no demographic differences between genders. Overall, 104 (23.5%) of 443 patients with sepsis died. The difference in mortality rates between female and male patients was not significant[4]

**Etiology of Sepsis in Patients Admitted to ICU**

Among the 120 patients in this study, most patients had respiratory system as their source of infection (45%). The next common etiology being urinary tract infection, observed in 36 patients (30%). The most common sites of infection as described by John M. Golsmid and Peter A. Leggat in Australasain College of tropical medicine publication was respiratory and urinary tract as the source of infection. The respiratory and genitourinary systems combined are the source in 65.3% of patients with sepsis aged ≥65 years, vs. only 49.3% in those younger patients. In comparison, younger patients are at higher risk of gastrointestinal sources, skin, bone, and soft tissue sources compared to older adults[5]. A prospective observational study was carried out at intensive care unit in Northwest General Hospital and Research Centre, Peshawar, Pakistan by Arslan Rahat Ullah, Arshad Hussain, Iftikhar Ali, Abdul Samad, Syed Tajammuli Ali Shah, Muhammad Yousef and Tahir Mehamood Khan from February 2014 to October 2015 showed that The most common source of sepsis was lung infections (42.2%) followed by urinary tract infections (18.7%), soft tissue infections (6.3%) abdominal infections (6%) and in 6.3% patients the source remained unknown.[6]

**Analysis of the 3 Scoring System APACHE II, SAPS II, SOFA Scoring System**

The mean score was calculated for the two groups using APACHE II scoring system, which was 17±7.2 for patients who survived and 25.5±9.1 for patients who did not survive. The difference in mean was 8.5. Test of significance showed p value of <0.001 which is highly significant. Hence the mean value of APACHE II scoring system between the two groups had significant difference and helps in determining the outcome of the patient. The mean score was calculated for the two groups using SAPS II scoring system, which was 45.7±14.2 for patients who survived and 56.3±19.5 for patients who did not survive. The mean difference between the two groups was 19.6. Test of significance between the two groups showed p value of <0.001 which is highly significant. And hence SAPS II scoring system is useful in detecting the outcome of the patients. The mean score was calculated for the two groups using SOFA scoring system which was 8.1±3.6 for patients who survived and 11.6±4.2 for patients who did not survive. The mean difference between the two groups was 3.5. The test of significance was calculated for means between 2 groups showed p value of <0.001 which was highly significant. And hence SOFA scoring system is useful in determining the outcome of the patient.

**Sofa Scoring System and its Trend in Predicting Outcome**

The trend of sofa score was grouped as increasing, static and decreasing trend. When the sofa score

had increasing trend, the 34 (79%) patients did not survive and 1 patient survived. Whereas when the patient had a decreasing trend sofa score 3 patients did not survived (7%) and 57 patients (74%) survived. The test of significance was calculated between the two groups for the trend in changing sofa score which showed a p value of <0.001 which is highly significant. And hence calculating the serial sofa scores gives good prediction about the outcome of the patient. Studies conduted in ICU of a Government Medical College, Chandigarh, a tertiary care hospital by Aditi Jain, Sanjeev Palta, Richa Saroa, Anshu Palta, Sonu Sama and Satinder Gombar, showed that the decreasing trend of SOFA score in survivors (3.92 ± 2.17) was statistically significant compared to the increasing trend in the non survivors (8.9 ± 3.45)[7].

**Pediction of Mortality Cut Off Points**

The three scoring systems namely APACHE II, SAPS II and SOFA was compared among the sepsis patients who were admitted in ICU between the patients who survived and did not survive. The scores were calibrated using Lemeshow and Hosmer goodness of fit test and discriminated by area under the ROC curve. The 3 scoring system was plotted as ROC curve and the area under the ROC curve was analysed to see which scoring system had better area. The area under the ROC curve was determined for each scoring system to identify which scoring system had better mortality prediction. SAPS II had higher area of 0.782 compared to APACHE II 0.764 and SOFA 0.733. A prospective cohort study in a 19 bed medico-surgical ICU in a private hospital, by G Nobre, M Kalichsztein, J Kezen, F Braga, G Almeida, G Penna, P Kurtz, P Araujo, R Vegni, M Freitas and C Valdez showed that the most area under the ROC curve was 0.0887 (95% CI 0.743 – 1.032) for the SAPS II, among APACHE II, SAPS II and SOFA scores. The best cutoff value was 39.5 points, and the sensitivity and specificity were 85.7% and 88.9%, respectively. The SAPS 2 mean predicted mortalities for patients with score <39.5 and ≥ 39.5 were 6.31 ± 0.48% and 48.7 ± 7.5%, respectively.[8]

LOGISTIC REGRESSION EQUATION OF APACHE II, SAPS II AND SOFA SCORING SYSTEM

The three scoring system was analysed using Wald $\chi^2$ test to find the best scoring system in predicting the mortality among the 3 scoring system. The analysis showed that SAPS II scoring system had wald $\chi^2$ value of 3.953 and when It was compared with other 2 scoring system its p value was 0.047($p< 0.05$) which is statistically significant and hence SAPS II scoring system predicts mortality better than the other 2 scoring systems. The Odds ratio of SAPS II was 1.449 which was higher than APACHE II AND SOFA scoring systems. A study was conducted on 84 patients with severe sepsis and septic shock admitted to the Medical ICU in JIPMER a tertiary care teaching hospital by Ajay Somabhai Dabhi, Suhas S Khedekar and Vadivelan Mehalingam corresponding author showed that the Mean of Predicted Mortality Rate (PMR) for APACHE-IV was 37.85% and for SAPS-II, it was 72.36% which shows that APACHE-IV had under-predicted overall mortality while SAPS-II had over-predicted overall mortality of patients with severe sepsis and septic shock. Standardised Mortality Rate for APACHE-IV was 1.60 and for SAPS-II, it was 0.83[9].

**Conclusion**

In this study the three scoring system were compared. SAPS II scoring system had better mortality predicting ability than the APACHE II and SOFA scoring system. Individually, all the three scoring systems can be used to detect the outcome of the patient with sepsis and severe sepsis.

Conflict of interest none.

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