*Original Research Article*

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# Comparison of Acute Physiology and Chronic Health Assessment II (APACHE II) Score and Sequential Organ Failure Assessment (SOFA) Score as A Mortality Predictor in ED-ICU Patients

**Hariprasad Kanakapura Veerendranath[1], Ravikanti Karthik[2], Murali Mohan NT[3], Gaganam Trimurty[4], Siddraj Wali[5]**

**Author's Affiliation:**
[1]Assistant Professor, Department of Emergency Medicine, Ramaiah Medical College, Mathikere, Bengaluru, Karnataka 560054, India. [2]Assistant Professor, [3]Professor and Head, [4]Professor, [5]Assistant Professor, Department of Emergency Medicine, Vydehi Institute of Medical Sciences and Research Centre, Nallurhalli, Whitefield, Bengaluru, Karnataka 560066, India.

**Corresponding Author:**
**Ravikanti Karthik, Assistant Professor**, Department of Emergency Medicine, Vydehi Institute of Medical Sciences and Research Centre, Nallurhalli, Whitefield, Bengaluru, Karnataka 560066, India.

**E-mail:** karthik.ravikanti@yahoo.in

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**Abstract**

*Background and Objectives:* Currently the Acute physiology and chronic health Assessment II (APACHE II) scoring system is widely used. A controversy exists as to which is an ideal scoring system so we conducted a study to assess and compare the effectiveness of Apache II score and sequential organ failure assessment (SOFA) score for the same patients. *Materials and Methods:* A prospective clinical study was undertaken over a period of 18 months including a total of 80 patients admitted in the ED-ICU of the Department of emergency medicine and the Multi-disciplinary ICU at a tertiary care hospital. *Results:* Out of the 80 patients admitted in the ED-ICU, both APACHE II scoring and SOFA scoring had a strong significant statistical relationship ($p \leq 0.01$) by fisher exact test with the outcomes. When multivariate logistic regression analysis was done there was no strong significant statistical correlation between APACHE II (24 hour) and mortality (adjusted odds ratio, 1.09; 95% CI 0.90–1.31; $p = 0.371$) but SOFA score had a logit coefficient of 0.53 and a high value on the Wald test =3.92 and hence a stronger statistical correlation with mortality ($p = 0.048$). *Conclusion:* We can conclude that SOFA score is better than APACHE score purely as a predictor of mortality and that SOFA score and cardiac events during stay in the ED-ICU are both individual predictors of mortality.

**Keywords:** APACHE II, SOFA, ED-ICU, Mortality

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## Introduction

The ED-ICU is a specialized area of the hospital entrusted with delivering care to acutely ill and emergent patients in major hospitals across the country. An important purpose of emergency intensive care is early stabilization of patients with medical and surgical emergencies and thereby attempt to alter the course of hospital stay. The pursuit for better and early critical care has encouraged varied researchers to devise scoring systems that would be helpful in predicting the

outcome from critical illness. The concept of providing cost effective intensive care is a topic of interest in developing countries among clinicians, hospital administrations, health care managers, medical economists and governmental policy makers.[1] Therefore for clinical and administrative purposes a good number of disease/patient severity scoring systems have been developed by applying linear regression models to prospectively collected data.[2–8] These scores assist in assessing efficacy of care delivered, in-hospital mortality risk and overall performance of the ED-ICUs.[1]

The final consequence of critical care provided in the ED and the multi-disciplinary ICU depends on multiple variables recorded on the day of presentation to the ED and during the course in the multi-disciplinary ICU. The severity scores often consist of two components: the score itself and a probability model. The score is always a number (the highest number, the highest severity). The probability model is an equation giving the probability of hospital death of the patients.[1] Most scores are calculated from data collected on the day one of ED-ICU stay; these include the Acute Physiology and Chronic Health Evaluation (APACHE), Simplified Acute Physiology Score (SAPS), and Mortality Prediction Model (MPM).[2]

Some scoring systems are calculated everyday throughout the ICU stay or for the first 3 days; these include the Organ System Failure (OSF), Organ Dysfunction and Infection System (ODIN), Sequential Organ Failure Assessment (SOFA), Multiple Organs Dysfunction Score (MODS), Logistic Organ Dysfunction (LOD) model, and Three-Day Recalibrating ICU Outcomes (TRIOS).[2]

Sepsis is now a common presentation to emergency departments across the country and the world and is steadily increasing in incidence.[3,4] It is present in up to 15% of critically ill patients requiring intensive care, and results in impairments and in many cases failure of organ system functions.[5,6] Any documented organ dysfunction is one of the reasons for providing care in the ED-ICU or the multidisciplinary ICU.[7]

The severity of inflammatory response and the ensuing organ dysfunction are the key determinants of the outcome in critically ill septic patients. An overall trend witnessed over last decade in several multicenter studies is toward improved outcomes.[3,4,8,9]

Severe sepsis is the combination of sepsis and related organ dysfunction. Emergency and critical care physicians find it helpful to use a scoring system for the assessment of the severity of organ function impairment. Most of these systems are based on the number and degree of organ dysfunction. Another key feature of the scoring systems is the measurement of the type and severity of physiologic function derangement by summing the points of dysfunction from six key organ systems: cardiovascular, respiratory, neurological, renal, hepatic, and coagulation.

### *Aim*

Evaluate scoring systems for optimization of hospital resources

### *Objectives:*

- Compare the performance of the APACHE II score with that of SOFA score as a mortality predictor.
- Correlation of findings in critically ill patients and calculating APACHE II and SOFA score and predicted mortality

## Materials and Methods

Over 18 months all the patients admitted in the ED-ICU of the department of emergency medicine.

### *Inclusion Criteria*

- All patients presenting to emergency department and admitted in the ED-ICU with evidence of organ dysfunction
- Patients with SIRS
- Patients with sepsis and septic shock
- Age ≥ 16 years
- Patients with cardiogenic shock
- Polytrauma requiring ED-ICU admission

### *Exclusion criteria*

- Age < 16 years
- Patients who get discharged against medical advice which prevents follow up on outcome
- Post-op patients
- Patients whose duration of stay less than 24 hours
- On-going pregnancy
- Patients in whom any of the 12 physiological variables are missing

### *Statistical Methods*

Descriptive and inferential statistical analysis has been carried out in the present study. Results on continuous measurements are presented on Mean ± SD (Min-Max) and results on categorical measurements are presented in Number (%). Significance is assessed at 5% level of significance.[10] Chi-square/Fisher Exact test has been used to find the significance of study parameters on categorical scale between two or more groups. Multivariate Logistic regression analysis used to predict the probability of death using several variables including APACHE II and SOFA score.[11]

## Results

In this study, among the 80 patients admitted in ED-ICU 55 patients (68.8%) were males and 25 patients (31.3%) were female. Highest occurrence of ED-ICU admission was males of 31–40 years age group, i.e. 16 patients (29.1%) followed by 13 male patients (23.6%) in 51–60 years age group. No female patients were in the age group of > 80 years. There was no statistical significance between Age and gender of the patients ($p$ = 0.154, Fisher Exact test)

Among the 80 patients admitted in ED-ICU, 50 patients (62.5%) were diabetic. 56.4% of the male patients were diabetic whereas 19 out of the 25 female patients (76%) were known Type II diabetes which is statistically significant ($p$ = 0.093 +, chi-square test). Other parameters like hypertension, Ischemic heart disease showed no significant statistical correlation. We also found that among the 80 patients admitted in the ED-ICU, 31 patients (38.8%) had a cardiac event during their admission which may or may not have been fatal. Out of the 31 patients 25 are male and 6 females. Only 24% of the female patients admitted had a cardiac event as compared to 45.5% of the male patients. There is a significant statistical relationship between patients admitted to ED-ICU and cardiac events during admission. ($p$ = 0.068+, chi-square test).

We found that there is no significant statistical relationship between patients admitted to ED-ICU and presence of shock ($p$ = 0.346, chi-square test) and also between patients admitted to ED-ICU and incidence of sepsis ($p$ = 0.922, chi-square test).

Among the 80 patients admitted in the ICU/ACU, 38 patients (47.5%) had a predicted mortality by APACHE II (24 hour) between 1–25%. 18 patients (22.5%) had predicted mortality between 51–75% and only 8 patients had a predicted mortality more than 75% (Table 1 and Fig. 2).

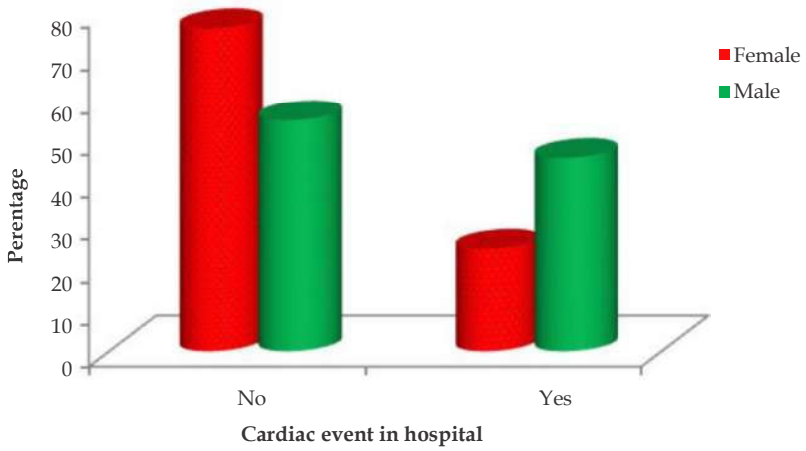


**Fig. 1:** Cardiac events in Hospital

**Table 1:** Predicted mortality by APACHE II score

| Predicted mortality | No. of patients | % |
|---|---|---|
| 1–25 | 38 | 47.5 |
| 26–50 | 16 | 20.0 |
| 51–75 | 18 | 22.5 |
| 75–100 | 8 | 10.0 |
| **Total** | 80 | 100.0 |

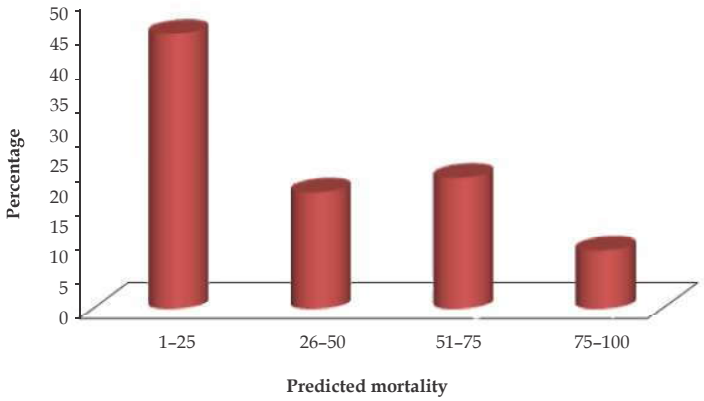


**Fig. 2:** Predicted mortality by APACHE II score

Among the 80 patients admitted in the ED-ICU, 31 patients (38.8%) had a predicted mortality by SOFA (Table 2,3 and Fig. 3) between 20–60%. 22 patients (27.5%) had predicted mortality between 10–20% and 15 patients (18.8%) had a predicted mortality more than 80%. Among the 80 patients admitted in the ED-ICU, 40 patients (50%) were discharged to the wards for further care, 35 patients (43.8%) of the patients expired and 5 patients (6.3%) were discharged against medical advice to another hospital and were not followed up to note outcome. Among the 80 patients admitted in the ED-ICU, APACHE II scoring was done for all the patients and when the score was correlated to the outcome, there was a strong significant statistical relationship ($p$ = <0.01) by Fisher Exact test (Tables 4,5 and Figs. 4,5).

**Table 2:** SOFA score in patients studied

| SOFA Score | No. of patients | % |
|---|---|---|
| 0–9 | 35 | 43.8 |
| 10–19 | 44 | 55.0 |
| 20–24 | 1 | 1.3 |
| **Total** | 80 | 100.0 |

**Table 3:** Predicted mortality SOFA

| Predicted mortality SOFA | No. of patients | % |
|---|---|---|
| <10% | 12 | 15.0 |
| 10–20% | 22 | 27.5 |
| 20–60% | 31 | 38.8 |
| 60–80% | 0 | 0.0 |
| >80% | 15 | 18.8 |
| **Total** | 80 | 100.0 |

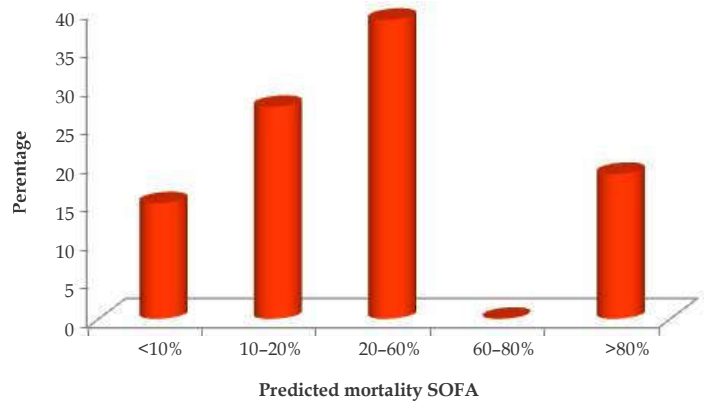


**Fig. 3:** Predicted Mortality SOFA

**Table 4:** APACHE II (24 hours) in correlation with outcome of patients studied

| Apache II (24 hours) | Outcome | | | Total |
|---|---|---|---|---|
| | Discharged | Expired | DAMA | |
| 1–10 | 9 (22.5%) | 0 (0%) | 0 (0%) | 9 (11.3%) |
| 11–20 | 24 (60%) | 5 (14.3%) | 3 (60%) | 32 (40%) |
| 21–30 | 6 (15%) | 21 (60%) | 1 (20%) | 28 (35%) |
| 31–40 | 1 (2.5%) | 7 (20%) | 1 (20%) | 9 (11.3%) |
| >40 | 0 (0%) | 2 (5.7%) | 0 (0%) | 2 (2.5%) |
| **Total** | 40 (100%) | 35 (100%) | 5 (100%) | 80 (100%) |

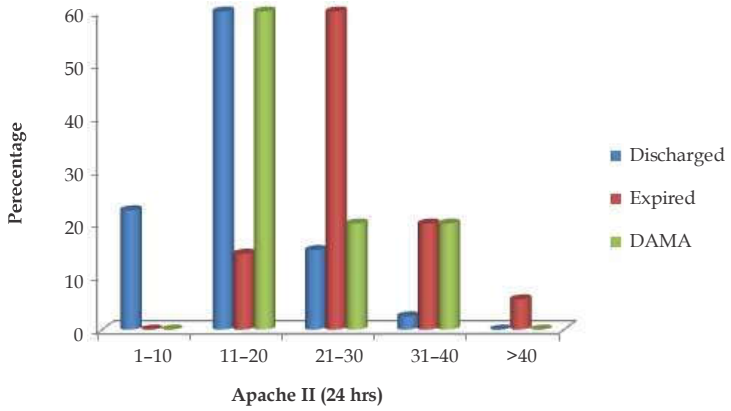


**Fig. 4:** APACHE II (24 hours) in correlation with outcome of patients studied

**Table 5:** SOFA Score in correlation with outcome of patients studied

| SOFA Score | Outcome | | | Total |
|---|---|---|---|---|
| | Discharged | Expired | DAMA | |
| 0–9 | 30 (75%) | 4 (11.4%) | 1 (20%) | 35 (43.8%) |
| 10–19 | 10 (25%) | 30 (85.7%) | 4 (80%) | 44 (55%) |
| 20–24 | 0 (0%) | 1 (2.9%) | 0 (0%) | 1 (1.3%) |
| **Total** | 40 (100%) | 35 (100%) | 5 (100%) | 80 (100%) |

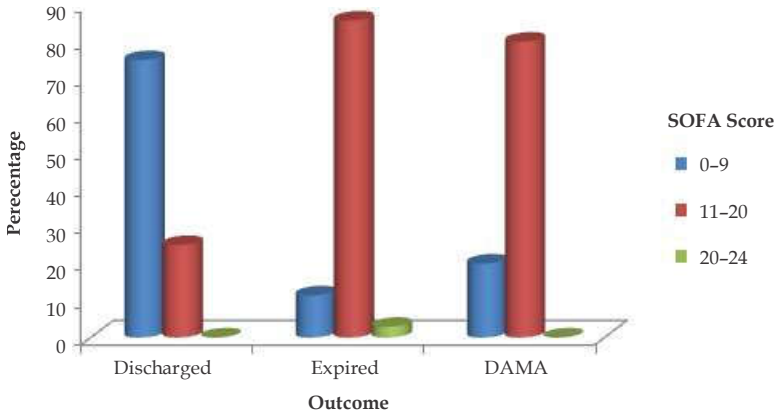


**Fig. 5:** SOFA Score in correlation with outcome of patients studied

Multivariate Logistic regression analysis was done to assess all the risk factors of death and their relative independent contribution to the death outcome (Table 6). APACHE II (24 hours) had a logit coefficient of 0.09 and a low value on the Wald test =0.80. There was NO strong significant statistical correlation between APACHE II (24 HRS) and mortality in a multivariate logistic regression analysis (adjusted odds ratio, 1.09; 95% CI 0.90–1.31; $p = 0.371$). SOFA score had a logit coefficient of 0.53

and a high value on the Wald test = 3.92. There was strong significant statistical correlation between SOFA score and mortality in a multivariate logistic regression analysis (adjusted odds ratio, 1.70; 95% CI 1.01-2.89; $p$ = 0.048). Cardiac events during stay in the ED-ICU had a logit coefficient of 3.16 and a high value on the wald test = 4.55. There was strong significant statistical correlation between cardiac events and mortality (adjusted odds ratio, 23.50; 95% CI 1.29–428.09; $p$ = 0.033)

**Table 6:** Multivariate Logistic regression analysis to assess the risk factors of death

| Variables | Logistic regression results to predict the death | | | | | 95% CI | |
|---|---|---|---|---|---|---|---|
| | Logit co-efficient | SE | Wald test | *p*-value | Adjusted OR | Lower | Upper |
| Age in years | 0.01 | 0.05 | 0.03 | 0.853 | 1.01 | 0.92 | 1.11 |
| Type II DM | 3.34 | 2.18 | 2.36 | 0.124 | 28.34 | 0.40 | 2019.29 |
| HTN | –2.34 | 1.81 | 1.68 | 0.194 | 0.10 | 0.00 | 3.30 |
| IHD | 1.48 | 1.87 | 0.63 | 0.426 | 4.41 | 0.11 | 171.38 |
| Cardiac events | 3.16 | 1.48 | 4.55 | 0.033 | 23.50 | 1.29 | 428.09 |
| Shock | 0.83 | 1.33 | 0.39 | 0.532 | 2.29 | 0.17 | 30.99 |
| Sepsis | –2.33 | 1.84 | 1.60 | 0.207 | 0.10 | 0.00 | 3.61 |
| Mechanical ventilation | 2.76 | 2.02 | 1.86 | 0.172 | 15.87 | 0.30 | 839.76 |
| Blood products | 1.05 | 1.69 | 0.39 | 0.533 | 2.86 | 0.10 | 78.45 |
| APACHE II 24 hours | 0.09 | 0.10 | 0.80 | 0.371 | 1.09 | 0.90 | 1.31 |
| SOFA score | 0.53 | 0.27 | 3.92 | 0.048 | 1.70 | 1.01 | 2.89 |

## Discussion

A lot of research has been done with regard to scoring systems for critically ill patients. Pettila and colleagues in a single center study reported that the discriminative power of APACHE III, LODS, SOFA, and MODS to predict hospital mortality was rather comparable.[12] Similarly Peres Bota and colleagues in their study found no significant differences between MODS and SOFA for mortality prediction in 949 general ICU patients.[13] However, when using the cardiovascular component, outcome prediction was better for the SOFA score at all time intervals compared to the MODS, a finding confirmed by other studies.[14] In a multicenter study, Timsit and colleagues found that there was good accuracy and internal consistency for both the SOFA and LODS.[15] SOFA score was also reported to have superior discriminative ability for hospital mortality and unfavorable neurologic outcome compared to MODS in patients with brain injury.

Similar to our research Innocenti F et al. attempted to identify a reliable tool for the early prognostic stratification of septic patients admitted to the emergency department-high dependency unit (ED-HDU). Mortality in Emergency Department Sepsis (MEDS), Acute Physiology Age Chronic Health Evaluation II (APACHE II), Simplified Acute Physiology Score II (SAPS II), Sequential Organ Failure Assessment (SOFA) scores (SOFA-T0) and the Charlson index was calculated at ED admission. The authors repeated the SOFA score at 24 hours (SOFA-T1) which they found to have the best ability to predict 28-day mortality (area under the curve 0.80, 95% confidence interval 0.70–0.91), when compared with MEDS, SAPS, and APACHE score. This conforms to the results of our study and the authors also performed a regression analysis adjusted for age, lactate value, and SOFA-T1 (RR 1.551, 95% confidence interval 1.204–1.998, $p$ < 0.001) maintained an independent prognostic value for 28 days mortality.[16]

R. Moreno et al. conducted a prospective, multicentre and multinational study in forty intensive care units (ICUs) in Australia, Europe, North and South America where they attempted to evaluate the performance of total maximum SOFA score and a derived measure, delta SOFA (total maximum SOFA score minus admission total SOFA) as a marker of multiple organ dysfunction in ICU patients. They found that the mean total maximum SOFA score presented a very good correlation to ICU outcome, with mortality rates ranging from 3.2% in patients without organ failure to 91.3%in patients with failure of all the six organs.[17]

Analogous to our study where we found that cardiac events during admission have a good

correlation with mortality and is itself an individual predictor of mortality, authors in this study too found that the cardiovascular score (odds ratio 1.68) was associated with the highest correlation with outcome as was delta SOFA.

Therefore, the authors concluded that the total maximum SOFA score and delta SOFA can be used to quantify the degree or severity of dysfunction/ failure of organ systems already present on admission, worsening of the same parameters during stay and overall the collective organ damage suffered by the patient. These qualities of this scoring system make it apt for use in ED-ICU and multidisciplinary ICU alike.

In another study similar to our study by Q-Qiao et al. to evaluate performances of the APACHE II score and the SOFA score in predicting mortality outcome in critically ill elderly patients. They found that mean APACHE II and SOFA scores in survivors were lower than in those who died. They have also reported a positive correlation between the APACHE II and SOFA scores and thus concluded that APACHE II and SOFA scores can accurately predict mortality outcome in critically ill elderly patients, especially the maximum SOFA score and the difference between the maximum and initial SOFA scores.[18]

In our study too APACHE II had a good correlation between the outcomes especially in the group with low predicted mortality unlike SOFA score where patient expired even with a low SOFA-predicted mortality. We concluded that SOFA score is better than APACHE score purely as a predictor of mortality and that SOFA score and cardiac events during stay in the ICU/ACU are both individual predictors of mortality. We also concluded that SOFA score is a reliable predictor model for use in the Emergency department ICU and not just in the intensive care unit either alone or with APACHE II score.

### *List of Abbreviations*

- APACHE II: Acute Physiology and Chronic Health Assessment
- SOFA: Sequential Organ Failure Assessment
- ICU: Intensive Care Unit
- SD: Standard Deviation
- DM: Diabetes Mellitus
- HTN: Hypertension
- IHD: Ischemic Heart Disease
- SAPS: Simplified Acute Physiology Score
- MPM: Mortality Probability Model
- OSF: Organ System Failure
- ODIN: Organ Dysfunction and Infection System
- MODS: Multi-Organ Dysfunction Syndrome/Score
- LOD: Logistic Organ Dysfunction
- TRIOS: Three-Day Recalibrating ICU Outcomes Score
- MV: Mechanical Ventilation
- SMR: Standardized Mortality Ratio
- ROC: Receiver Operating Characteristic Curve
- ED-ICU: Emergency Department- Intensive Care Unit
- OR: Odds Ratio

### References

1. Ratanarat R, Thanakittiwirun M, Vilaichone W, et al. Prediction of Mortality by Using the Standard Scoring Systems in a Medical Intensive Care Unit in Thailand. J Med Assoc Thai 2005;88(7):949–55.
2. Le Gall J. The use of severity scores in the intensive care unit. Intensive Care Med 2005;31(12):1618–23.
3. Kasal J, Jovanovic Z, Clermont G, et al. Comparing Gray's and Cox models in sepsis survival. Critical Care 2001;5(Suppl 1):P248.
4. Martin G, Mannino D, Eaton S, Moss M. The Epidemiology of Sepsis in the United States from 1979 through 2000. New England Journal of Medicine 2003;348(16):1546–54.
5. Brun-Buisson C. Incidence, risk factors, and outcome of severe sepsis and septic shock in adults. A multicenter prospective study in intensive care units. French ICU Group for Severe Sepsis. JAMA: The Journal of the American Medical Association. 1995;274(12):968–74.
6. Cohen J, Guyatt G, Bernard G, et al. New strategies for clinical trials in patients with sepsis and septic shock. Critical Care Medicine. 2001;29(4):880–86.
7. Vincent J, de Mendonca A, Cantraine F, et al. Use of the SOFA score to assess the incidence of organ dysfunction/failure in intensive care units. Critical Care Medicine 1998;26(11):1793–1800.
8. Bernard G, Vincent J, Laterre P, et al. Efficacy and Safety of Recombinant Human Activated

Protein C for Severe Sepsis. New England Journal of Medicine 2001;344(10):699–09.

9. Rivers E, Nguyen B, Havstad S, et al. Early Goal-Directed Therapy in the Treatment of Severe Sepsis and Septic Shock. New England Journal of Medicine 2001;345(19):1368–77.
10. Rosner b. Fundamentals of biostatistics. 5th ed. duxbury; 2000.
11. Riffenburg r. statistics in medicine. 2nd ed. academic press; 2005.
12. Pettilä V, Pettilä M, Sarna S, et al. Comparison of multiple organ dysfunction scores in the prediction of hospital mortality in the critically ill*. Critical Care Medicine 2002;30(8):1705–11.
13. Peres Bota D, Melot C, Lopes Ferreira F, et al. The Multiple Organ Dysfunction Score (MODS) versus the Sequential Organ Failure Assessment (SOFA) score in outcome prediction. Intensive Care Medicine 2002;28(11):1619–24.
14. Zygun D, Laupland K, Fick G, et al. Neuroanesthesia and Intensive Care Limited ability of SOFA and MOD scores to discriminate outcome: a prospective evaluation in 1,436 patients. Can J Anesth/J Can Anesth 2005;52(3):302–08.
15. Timsit J, Fosse J, Troché G, et al. Accuracy of a composite score using daily SAPS II and LOD scores for predicting hospital mortality in ICU patients hospitalized for more than 72 h. Intensive Care Med 2001;27(6):1012–21.
16. Innocenti F, Bianchi S, Guerrini E, et al. Prognostic scores for early stratification of septic patients admitted to an emergency department-high dependency unit. European Journal of Emergency Medicine 2014;21(4):254–59.
17. Moreno R, Vincent JL, Matos R, et al: The use of maximum SOFA scores to quantify organ dysfunction/failure in intensive care. Results of a prospective, multicentre study. Intensive Care Med 1999;25:686–96.
18. Qiao Q, Lu G, Li M, et al. Prediction of Outcome in Critically Ill Elderly Patients using APACHE II and SOFA Scores. Journal of International Medical Research 2012;40(3):1114–21.