

## ICU SCORING SYSTEMS (APACHE II, APACHE IV, SAPS III) IN AN INDIAN ICU - OBSERVED MORTALITY AND ITS CORRELATION WITH PREDICTED MORTALITY

Vimal Kumar Palaniappan<sup>1</sup>, Nirmal Kumar Palaniappan<sup>2</sup>, Vivekanandan M<sup>3</sup>, Sagiev Koshy George<sup>4</sup>

<sup>1</sup>Assistant Professor, Department of General Medicine, Vinayaka Mission's Kirupananda Variyar Medical College and Hospitals, Salem.

<sup>2</sup>Assistant Professor, Department of General Surgery, Pondicherry Institute of Medical Sciences, Kalapet, Puducherry.

<sup>3</sup>Additional Professor, Department of General Medicine, JIPMER, Puducherry.

<sup>4</sup>Professor, Department of Anaesthesiology, Pondicherry Institute of Medical Sciences, Kalapet, Puducherry.

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### ABSTRACT

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#### BACKGROUND

Intensive care has developed over the past four decades in treating critically-ill patients. The cost of providing the intensive care services are also squaring up to astronomical levels. Risk scoring systems can be used to focus on quality of care provided to patients at ICU setup as they help in comparative audit that is comparison of actual and expected outcome for group of patients that can be used to compare different providers.

The aim of the study is to-

1. Study the usefulness of ICU scoring systems (APACHE II, APACHE IV and SAPS III) developed in the west in an Indian ICU.
2. Calculate scores of patients admitted in our ICU as per various ICU scoring systems (APACHE II, APACHE IV and SAPS III).
3. To document the observed mortality among these patients.
4. To compare the observed mortality with mortality predicted by scoring systems (APACHE II, APACHE IV and SAPS III) to see if these ICU scoring systems developed in the West can predict mortality in an Indian ICU.

#### MATERIALS AND METHODS

The study was a prospective study over a period of one year (2011-2012) and patients are enrolled as per inclusion criteria. Sample size was set to be a minimum of 100. The physiological parameters, lab investigations, surgical status, chronic health condition including the demographic details as needed by scoring systems (APACHE II, APACHE IV, SAPS III) were recorded at the time of admission to ICU. Patients were followed up till the time of discharge and mortality among the study patients were documented.

Statistical Analysis- Statistical analysis is done by using SPSS software.

#### RESULTS

This prospective study of 115 ICU patients evaluated the three ICU scoring systems namely, APACHE II, APACHE IV and SAPS III in ICU of a tertiary care corporate hospital shows there is a linear correlation between the scores and observed mortality with increasing scores, the observed mortality progressively increases. This suggests that the scoring systems are valid and can accurately predict mortality in Indian setting also the observed mortality in our cohort of patients is 40%. However, the predicted mortality as per APACHE II, APACHE IV, and SAPS III is only 33.51%, 33.5% and 28.53%. The risk of death for a given patient in our ICU with mean predicted mortality (SMR) is 1.2, 3.61 and 1.4 times that of the mortality predicted by scoring systems APACHE II, APACHE IV, and SAPS III, respectively. After obtaining the score for individual patients, the mortality predicted by the scoring systems should be multiplied by the above factor. Different ICU will have different SMR for any given scoring system depending on the standard of care of that particular ICU. So, individual intensive care units should establish their own SMR for any particular scoring system. SAPS III admission scoring in predicting mortality risk stands good as it is recorded within one hour of ICU admission and other scoring systems may be influenced by treatment. The limitations of the study are that the number of patients in the study is small to establish statistical significance. In addition, our study evaluated predominantly medical patients and may not be applicable to other types of ICU patients.

#### CONCLUSION

There is a linear correlation between the predicted scores and observed mortality with increasing scores, the observed mortality progressively increases. This suggests that the scoring systems are valid and can accurately predict mortality in Indian setting also.

#### KEYWORDS

Observed Mortality, Predicted Mortality, APACHE II, APACHE IV, SAPS III, Risk Scoring Systems in ICU.

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*Corresponding Author:*

*Dr. Nirmal Kumar Palaniappan,  
Assistant Professor, Department of General Surgery,  
Pondicherry Institute of Medical Sciences, Kalapet, Puducherry.  
E-mail: nirmal3106@gmail.com  
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## BACKGROUND

Intensive care has developed over the past four decades in treating critically-ill patients in a significant manner. Patient referred or admitted to ICU represent a broad spectrum of disease severity.

In the interest of allocating resources to patients who might potentially benefit from clinical interventions, several scoring systems have been used as a triaging tool.

Further the cost of providing the intensive care services are also squaring up to astronomical levels, which is a major burden to economy of a country, especially for developing countries like India.

So, there is a need to focus on the quality of healthcare provided to patients in ICU setup. Risk scoring systems can be used to focus on quality of care provided to patients at ICU setup as they help in comparative audit that is comparison of actual and expected outcome for group of patients that can be used to compare different providers.<sup>1</sup>

Apart from triaging, comparative audit, scoring systems have a number of proposed roles to mention a few such as use in clinical management of patients.<sup>1</sup> ICU and hospital mortality prediction, ICU and hospital length of stay, risk of needing active treatment during ICU stay, monitor effect of new technology and much more roles.

Thus, the need for risk scoring system in ICU is evident. The first ICU model of disease severity, The Therapeutic Intervention Scoring system (TISS) was proposed in 1974.<sup>2</sup> Since then, several physiology-based ICU prognostic models have emerged.

Most of the prognostic models focus on hospital mortality. The first generation of the ICU severity prognostic model has APACHE (Acute Physiology and Chronic Health Evaluation) scoring. Successive generations of ICU severity prognostic models have been developed.

Realising the utility of scoring system in mortality prediction of critically-ill patients admitted to ICU studies done so far suggest a need to validate the scoring systems for database of respective countries before they are used in decision making that impact the healthcare delivery and individual patient care. Among the several prognostic models, APACHE II (Acute Physiology and Chronic Health Evaluation II), APACHE IV (Acute Physiology and Chronic Health Evaluation IV) and SAPS III (simplified acute physiology score) are western scoring systems are taken for study to validate their use in mortality prediction in Indian ICU setup as severity scores can be calculated from the data obtained on the first day of ICU admission and not influenced by the treatment. The most commonly used ICU

scoring system (Apache II) was developed three decades back in 1985.<sup>3</sup>

APACHE II and APACHE IV uses a point score based on the values of 12 regular physiologic measurements, which is taken during the first 24 hours of admission including age and previous health status to provide a general measure of severity of disease. A score from 0 to 71 is computed based on these measurements. Higher score shows a more severe disease and a higher risk for death. The APACHE II score predicted hospital mortality of critically-ill patients better than other scoring systems.<sup>4</sup>

The APACHE IV model provides a useful ICU stay predictions for critically-ill patients, but its accuracy and utility is limited to individual patients and cannot be emphasised generally.<sup>5</sup> SAPS III is based on 20 different variables, which are easily measured within an hour on admission in ICU and allows early appraisal of risk, dissociating patient status from the quality of care. It has very good validity.<sup>6</sup>

## MATERIALS AND METHODS

The study was a prospective study over a period of one year (2011-2012) and patients are enrolled as per inclusion criteria. Sample size was set to be a minimum of 100.

Patients admitted in intensive care unit during study period were taken for study when they come under inclusion criteria.

The physiological parameters, lab investigations, surgical status, chronic health condition including the demographic details as needed by scoring systems (APACHE II, APACHE IV, SAPS III) were recorded at the time of admission to ICU.

No changes were made in treatment protocol of study patients. The treating physician/emergency medicine team in charge of ICU and staffs was unaware that patients are enrolled into the study. The study patients were given the same care as provided to all patients.

Patients were followed up till the time of discharge and mortality among the study patients were documented by the principal investigator to study the usefulness of ICU scoring systems (APACHE II, APACHE IV and SAPS III) developed in the west in an Indian ICU.

### Inclusion Criteria

Age  $\geq$  17 years.  
Patients admitted to ICU.  
Minimum ICU stay of 24 hours.

### Exclusion Criteria

Age < 17 years.

**Assessment of Data and Outcome-** The scores were calculated for study patients according to the scoring systems studied (APACHE II, APACHE IV and SAPS III).

APACHE II and APACHE IV scores were calculated using online calculators available at Middle East critical care assembly (An affiliate of Society of Critical Care Medicine) web portal.

SAPS III scores were calculated using the excel worksheet provided by SAPS3.org.

Also, predicted mortality by each scoring systems have been documented and analysed statistically to meet the objective of study.

**Statistical Analysis-** Statistical analysis is done by using SPSS software version.

**Ethical Consideration-** Study was approved by institute ethics committee. Written and informed consent was obtained from patients/relatives for data collection.

**RESULTS**

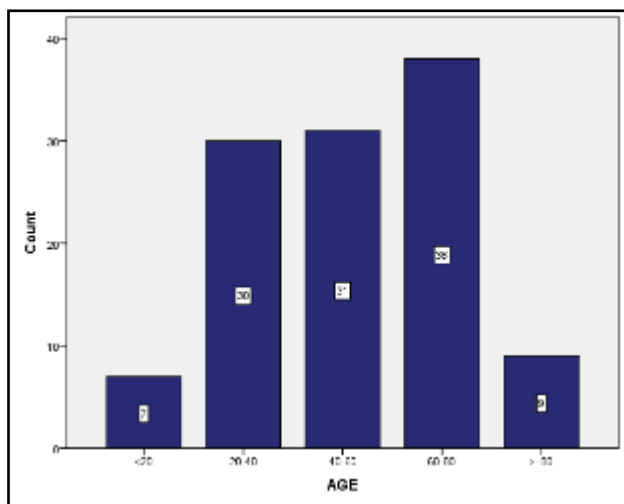
**Baseline Characteristics**

**A) Age Group-** Majority of the patients were above the age of 60 years.

Age	Frequency	Percentage
<20	7	6.1
20-40	30	26.1
40-60	31	27.0
60-80	38	33.0
>=80	9	7.8
<b>Total</b>	<b>115</b>	<b>100</b>

**Table 1. Shows Distribution of Patients by Age**

N = 115 (total number of patients in study), mean = 53.86.



**Chart 1. Shows Distribution of Patients by Age**

X-axis - Age group.  
Y-axis - Count of patients.  
More number of patients in age group of 60-80.

**B) Sex Distribution**

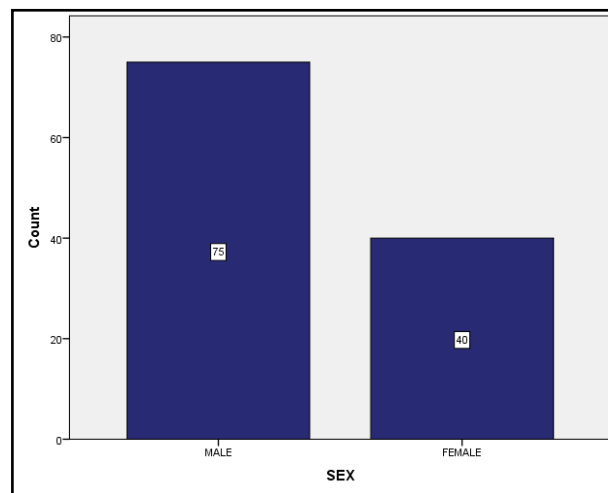
Sex	Frequency	Percentage
Male	75	65.2
Female	40	34.8
<b>Total</b>	<b>115</b>	<b>100</b>

**Table 2. Shows Distribution of Patients by Gender. Men 65.2% and Women 34.8%**

Total number of patients (N) = 115.

Male sex (n) = 75.

Female sex (n) = 40.



**Chart 2. Shows Distribution of Patients by Gender**

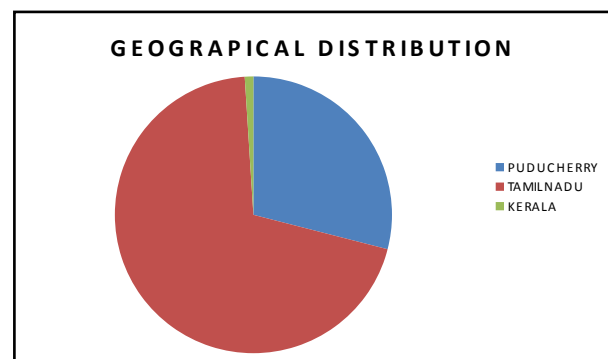
X-axis- Sex, Y-axis- Count of male/female sex, more number of patients is of male sex.

**C) Demographics**

State	Number of Patients	Percentage
Puducherry	33	29
Tamil Nadu	81	70
Kerala	1	1

**Table 3. Geographical Distribution**

Total number of patients (N) = 115, Puducherry (n) = 33, Tamil Nadu (n) = 81, Kerala (n) = 1.



**Chart 3. Geographical Distribution**

Majority of patients are from nearby districts of Puducherry belonging to Tamil Nadu state.

Study Results- APACHE II.

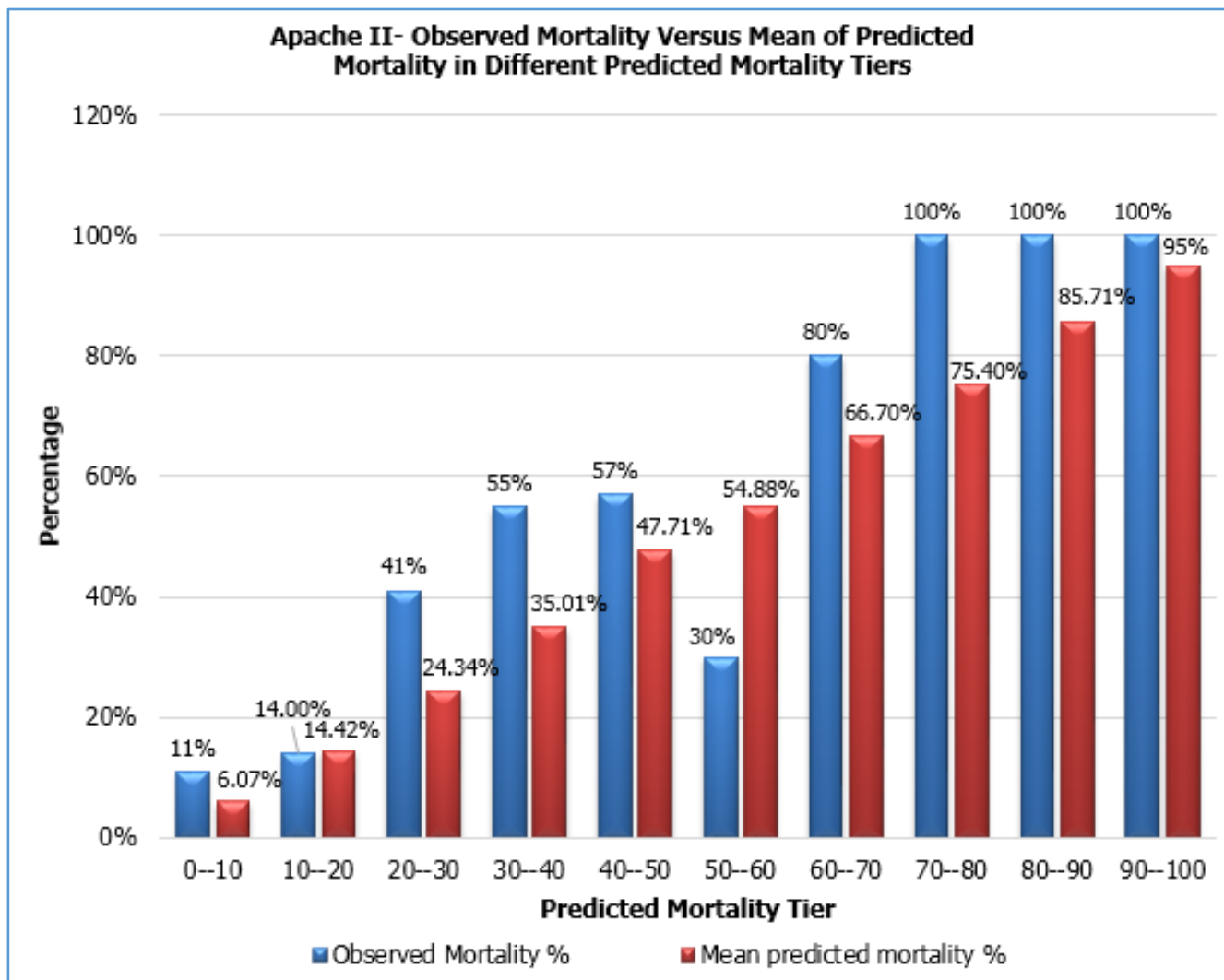
Predicted mortality refers to the mortality predicted by the APACHE II score in given patient.

The patients were divided into 10 tiers based on the predicted mortality.

Observed mortality refers to the mortality observed in our study.

Apache II- Predicted Mortality Tiers* Observed Mortality	Observed Mortality	
	Number Died (Total Patients within Tier)	Observed Mortality Percentage
Apache II Predicted Mortality Tiers	0-10	3 (27) 11%
	10-20	3 (21) 14%
	20-30	7 (17) 41%
	30-40	6 (11) 55%
	40-50	4 (7) 57%
	50-60	3 (10) 30%
	60-70	8 (10) 80%
	70-80	5 (5) 100%
	80-90	6 (6) 100%
	90-100	1 (1) 100%
<b>Total</b>	<b>46 (115)</b>	<b>40%</b>

**Table 4. Apache II- Predicted Mortality Tiers and Observed Mortality**



**Chart 4. Apache II- Correlation between Predicted Mortality Tier and Observed Mortality**

Table 4 and Chart 4 for APACHE II shows that as APACHE II score increases, there is linear and progressive increase in predicted mortality.

The patients were divided into 10 tiers based on the predicted mortality. The tiers are distributed as predicted mortality percentage against observed mortality. The percentage of predicted mortality in each tier (0-10)- 6.07%, (10-20)- 14.42%, (20-30)- 24.34%, (30-40)- 35.01%, (40-50)- 47.71%, (50-60)- 54.88%, (60-70)- 66.70%, (70-80)- 75.4%, (80-90)- 85.71% and (90-100)- 95%.

Observed mortality in APACHE II is always higher compared to predicted mortality. The observed mortality is 11% at the lowest tier and progressively increases as the score increases to 14%, 41%, 55%, 57%, 80% and reaches 100%, and above 70, it is 100% mortality irrespective of score significance. This establishes that there is a linear relationship between the score and observed mortality.

Predicted Mortality Tier	Number of Patients	Observed Mortality Number	Observed Mortality (%)	Mean Predicted Mortality (%)	SMR
0-10	27	3	11	6.07	1.8
10-20	21	3	14	14.42	1
20-30	17	7	41	24.34	1.7
30-40	11	6	55	35.01	1.6
40-50	7	4	57	47.71	1.2
50-60	10	3	30	54.88	0.5
60-70	10	8	80	66.70	1.2
70-80	5	5	100	75.4	1.3
80-90	6	6	100	85.71	1.2
90-100	1	1	100	95	1.1
<b>Total</b>	<b>115</b>	<b>46</b>	<b>40</b>	<b>33.51</b>	<b>1.2</b>

**Table 5. APACHE II- Observed Mortality Versus Mean of Predicted Mortality in Different Predicted Mortality Tiers with Standardised Mortality Ratio (SMR)**

The ratio of observed mortality to expected mortality is known as Standardised Mortality Ratio (SMR).

SMR (standardised mortality ratio) = Observed mortality/predicted mortality.

The above table shows the relation between observed mortality and predicted mortality for each tier. The ratio of observed mortality to expected mortality is known as Standardised Mortality Ratio (SMR).

$$\text{SMR (Standardised Mortality Ratio)} = \frac{\text{Observed Mortality}}{\text{Predicted Mortality}}$$

At the lowest tier, the ratio of observed mortality to mean of predicted mortality (SMR) is 1.8. The ratio varies in different tiers. The observed mortality in our cohort of patients is 40%. However, the predicted mortality as per APACHE II is only 33.51%. Overall, the ratio of observed mortality to mean predicted mortality (SMR) is 1.2%. Hence, the risk of death for a given patient in our ICU is 1.2 times that of the mortality predicted by APACHE II.

However, it should be noted that the SMR is not uniform across the tiers. It varies from 0.5 to 1.8. Hence, tier specific SMR can predict mortality more accurately.

**APACHE IV**

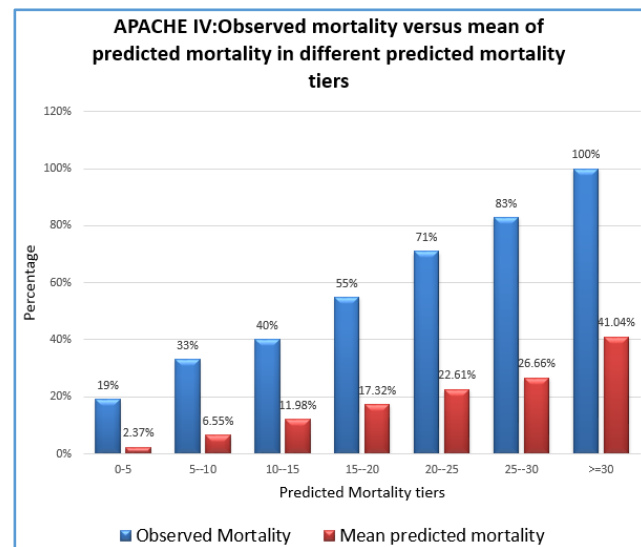
APACHE IV- Predicted Mortality Tiers * Observed Mortality	Observed Mortality	Observed Mortality
	Number Died (Total Patients within Tier)	Percentage
APACHE IV Predicted Mortality Tiers	0-5	9 (47) 19%
	5-10	6 (18) 33%
	10-15	8 (20) 40%
	15-20	6 (11) 55%
	20-25	5 (6) 83%
	25-30	5 (6) 83%
	>=30	6 (6) 100%
<b>Total</b>	<b>45 (115)</b>	<b>40%</b>

**Table 6. APACHE IV- Predicted Mortality Tiers and Observed Mortality**

Predicted mortality refers to the mortality predicted by the APACHE IV score in given patient.

The patients were divided into 7 tiers based on the predicted mortality.

Observed mortality refers to the mortality observed in our study.



**Chart 5. APACHE IV- Correlation between Predicted Mortality and Observed Mortality**

Table 6 and Chart 5 for APACHE IV show that as APACHE IV score increases, there is a linear and progressive increase in observed mortality.

The patients were divided into 7 tiers based on the predicted mortality.

The observed mortality is 19% at lower tier and progressively increases as 33%, 40%, 55% and 83% to 100%.

The percentage of predicted mortality in each tier (0-5)- 2.37%, (5-10)- 6.55%, (10-15)- 11.98%, (15-20)- 17.32%, (20-25)- 22.61%, (25-30)- 26.66%, (>=30)- 41.04%.

This establishes that there is a linear relationship between the score and observed mortality.

However, the observed mortality at each level of score is significantly higher than the predicted mortality.

Predicted Mortality Tier	Number of Patients	Observed Mortality Number	Observed Mortality (%)	Mean Predicted Mortality (%)	SMR
0-5	47	9	19%	2.37	8
5-10	18	6	33%	6.55	5
10-15	20	8	40%	11.98	3.3
15-20	11	6	55%	17.32	3.2
20-25	6	5	83%	22.61	3.7
25-30	6	5	83%	26.66	3.1
>=30	6	6	100%	41.04	2.4
<b>Total</b>	<b>115</b>	<b>45</b>	<b>40%</b>	<b>11.05</b>	<b>3.6</b>

**Table 7. APACHE IV- Observed Mortality Versus Mean of Predicted Mortality in Different Predicted Mortality Tiers with Standardised Mortality Ratio (SMR)**

The ratio of observed mortality to expected mortality is known as Standardised Mortality Ratio (SMR).

SMR (standardised mortality ratio) = Observed mortality/predicted mortality.

The above table shows the relation between observed mortality and predicted mortality for each tier.

At the lowest tier, the ratio of observed mortality to mean of predicted mortality (SMR) is 8. The ratio progressively decreases at higher level tiers to 2.4.

The observed mortality in our cohort of patients is 40%. However, the predicted mortality as per APACHE IV is only 11%. Overall, the ratio of observed mortality to mean predicted mortality (SMR) is 3.6%. Hence, the risk of death for a given patient in our ICU is 3.6 times that of the mortality predicted by APACHE IV.

However, it should be noted that the SMR is not uniform across the tiers. At the lower tier, it is 8, and at higher tier, it is 2.4.

Hence, tier specific SMR can predict mortality more accurately.

**SAPS III**

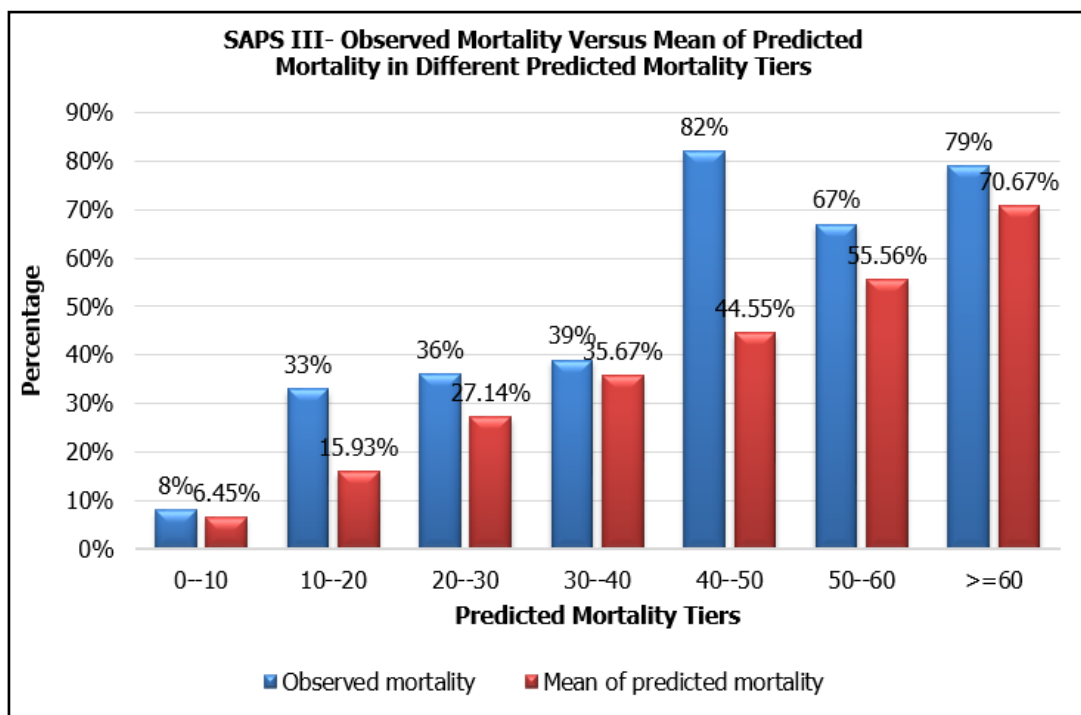
SAPS III- Predicted Mortality Tiers* Observed Mortality	Observed Mortality	Observed Mortality
	Number Died (Total Patients within Tier)	Percentage
SAPS III Predicted Mortality Tiers	0-10	2 (24) 8%
	10-20	10 (30) 33%
	20-30	5 (14) 36%
	30-40	7 (18) 39%
	40-50	9 (11) 82%
	50-60	6 (9) 67%
	>=60	7 (9) 79%
<b>Total</b>	<b>46 (115)</b>	<b>40%</b>

**Table 8. SAPS III- Predicted Mortality Tiers and Observed Mortality**

Predicted mortality refers to the mortality predicted by the SAPS III score in given patient.

The patients were divided into 7 tiers based on the predicted mortality.

Observed mortality refers to the mortality observed in our study.



**Chart 6. SAPS III- Correlation between Predicted Mortality Tiers and Observed Mortality**

Table 8 and Chart 6 for SAPS III show that as SAPS III score increases, there is a linear and progressive increase in observed mortality.

The patients were divided into 7 tiers based on the predicted mortality.

The percentage of predicted mortality in each tier (0-10)- 6.45%, (10-20)- 15.93%, (20-30)- 27.14%, (30-40)- 35.67%, (40-50)- 44.55%, (50-60)- 55.56%, (>60)- 70.67%.

The observed mortality is 8% at lower tier and progressively increases as 33%, 36%, 39%, 82%, 67% and 79% to 100%.

This establishes that there is a linear relationship between the score and observed mortality.

However, the observed mortality at each level of score is significantly higher than the predicted mortality.

Predicted Mortality Tier	Number of Patients	Observed Mortality Number	Observed Mortality (%)	Mean Predicted Mortality (%)	SMR
0-10	24	2	8%	6.45	1.2
10-20	30	10	33%	15.93	2.1
20-30	14	5	36%	27.14	1.3
30-40	18	7	39%	35.67	1.1
40-50	11	9	82%	44.55	1.8
50-60	9	6	67%	55.56	1.2
>=60	9	7	79%	70.67	1.1
<b>Total</b>	<b>115</b>	<b>46</b>	<b>40%</b>	<b>28.53</b>	<b>1.4</b>

**Table 9. SAPS III- Observed Mortality Versus Mean of Predicted Mortality in Different Predicted Mortality Tiers with Standardised Mortality Ratio (SMR)**

The ratio of observed mortality to expected mortality is known as Standardised Mortality Ratio (SMR).

SMR (standardised mortality ratio) = Observed mortality/predicted mortality.

The above table shows the relation between observed mortality and predicted mortality for each tier.

At the lowest tier, the ratio of observed mortality to mean of predicted mortality (SMR) is 1.2. The ratio differs at different levels. The observed mortality in our cohort of patients is 40%. However, the predicted mortality as per SAPS III is only 28.53%. Overall, the ratio of observed mortality to mean predicted mortality (SMR) is 1.4%. Hence, the risk of death for a given patient in our ICU is 1.4 times that of the mortality predicted by SAPS III.

However, it should be noted that the SMR is not uniform across the tiers. Hence, tier specific SMR can predict mortality more accurately.

**RESULTS**

The study is a prospective study of correlation between predicted and observed mortality using the ICU scoring systems APACHE II, APACHE IV and SAPS III. The study was done over a period of one year.

The total number of patients in the study is 115 and two-third of them are males. There is a linear correlation between the observed mortality with score and predicted mortality. With increasing scores, the observed mortality progressively increases. This suggests that the scoring systems are valid and can predict mortality in Indian setting also.

Even though, there is a linear correlation between the score and predicted mortality with observed mortality, the observed mortality is significantly higher than the predicted one. The mortality observed is 1.2, 3.61 and 1.4 times that of mortality predicted by scoring systems APACHE II, APACHE IV and SAPS III, respectively.

The SMR (standardised mortality ratio), the ratio between the observed mortality and mean predicted mortality for three scoring systems is as follows-

- Apache II- 1.2.
- Apache IV- 3.61.
- SAPS III- 1.4.

Thus, after obtaining scores for individual patients, the mortality predicted by the scoring system used should be multiplied by SMR for the particular scoring system.

**DISCUSSION**

This is a prospective study of ICU scoring systems APACHE II,<sup>7</sup> APACHE IV<sup>8</sup> and SAPS III<sup>9</sup> in predicting mortality. Total number of patients enrolled and analysed were 115.

Patients recruited into the study were of diversified age group from 17-91 and the mean age is 54. Majority of patients are in age group of 60-80 (Table 1, Chart 1).

The gender distribution among the study group comprises 65.2% ((n) = 76) male and 34.8% ((n) =40) females (Table 2, Chart 2).

Demographically, patients are from in and around Puducherry including districts of Tamil Nadu surrounding Puducherry (Table 3, Chart 3).

**APACHE II**

Based on the predicted mortality, patients were divided into tiers. The total of 115 patients were divided into 10 tiers (width = 10). This is done to see the correlation between the predicted and observed mortality over the range.

From Table 4, we can see the observed mortality is higher than the predicted mortality in each tier.<sup>10</sup> Chart 4 shows that there is a linear and progressive increase in mortality with increasing predicted mortality.

Table 5 shows the mean predicted mortality versus observed mortality in different predicted mortality tiers with Standardised Mortality Ratio (SMR). The observed mortality

in our cohort of patients is 40%. However, the predicted mortality as per APACHE II is only 33.51%.<sup>11</sup> Overall, the ratio of observed mortality to mean predicted mortality (SMR) is 1.2%. Hence, the risk of death for a given patient in our ICU is 1.2 times that of the mortality predicted by APACHE II.

However, it should be noted that the SMR is not uniform across the tiers. It varies in different tiers. Hence, tier specific SMR can predict mortality more accurately.

#### **APACHE IV**

With regard to APACHE IV system of ICU scoring in mortality prediction, the predicted mortality and observed mortality correlation and comparability is analysed by dividing the study population into seven tiers based on the predicted mortality.

From Table 6, we can see the observed mortality is higher than the predicted mortality in each. Chart 5 shows that there is a linear and progressive increase in mortality with increasing predicted mortality. Table 7 shows mean predicted mortality versus observed mortality in different predicted mortality tiers with Standardised Mortality Ratio (SMR). It's evident that the observed mortality is higher than predicted by APACHE IV scoring system. At the lowest tier, the ratio of observed mortality to mean of predicted mortality (SMR) is 8. The ratio progressively decreases at higher level tiers to 2.4.

The observed mortality in our cohort of patients is 40%. However, the predicted mortality as per APACHE IV is only 33.5%. Overall, the ratio of observed mortality to mean predicted mortality (SMR) is 3.6%. Hence, the risk of death for a given patient in our ICU is 3.6 times that of the mortality predicted by APACHE IV.

However, it should be noted that the SMR is not uniform across the tiers. It varies in different tiers. Hence, tier specific SMR can predict mortality more accurately.

#### **SAPS III**

Coming to mortality prediction analysis by SAPS III model of ICU scoring system from Table 8, it is evident that there is a progressive increase in observed mortality with increasing predicted mortality, but also the observed mortality is higher than the predicted mortality in each tier. Chart 6 shows that there is a linear and progressive increase in mortality with increasing predicted mortality.

Table 9 shows mean predicted mortality versus observed mortality in different predicted mortality tiers with Standardised Mortality Ratio (SMR). It is evident that the observed mortality is higher than predicted by SAPS III scoring system. The ratio varies in different tiers.

The observed mortality in our cohort of patients is 40%. However, the predicted mortality as per SAPS III is only 28.53%.<sup>12</sup> Overall, the ratio of observed mortality to mean predicted mortality (SMR) is 1.4%. Hence, the risk of death for a given patient in our ICU is 1.4 times that of the mortality predicted by SAPS III.

However, it should be noted that the SMR is not uniform across the tiers. It varies in different tiers. Hence, tier specific SMR can predict mortality more accurately.

The SMR (standardised mortality ratio), the ratio between the observed mortality and mean predicted mortality for three scoring systems is as follows.

For APACHE II - 1.2, APACHE IV - 3.61 and SAPS III - 1.4.

APACHE II, APACHE IV and SAPS III were commonly used in the west. APACHE II and SAPS III showed better discrimination compared to APACHE IV in our ICU population. APACHE IV had poor calibration. However, APACHE II was better compared to SAPS III as observed mortality is 1.2 times more than the predicted mortality in our results, which was similar with study results done with above scoring systems by Vincent JL et al.<sup>13</sup> Our predicted mortality as per APACHE II is 33.51%. These findings are similar to the study results done by Parikh CR et al<sup>14</sup> shows a predicted mortality of 21.7% and observed mortality of 36.2% in Indian intensive care. Intensive care in India is cheaper than in the West; however, mortality is 1.67 times that for patients with similar APACHE II scores in ICUs in the United States. In addition, the APACHE II scores may underestimate Indian patient's mortality because of differences in ICU admissions with mixed cases, late admissions and early age of onset of disease. APACHE IV predictions of hospital mortality had good discrimination and calibration in U.S. ICUs as studied by Zimmerman et al, but not evident in Indian ICU setup. The results from our study demonstrate that the APACHE IV prognostic scoring system observed mortality of 40% and predicted mortality of 33.5% and results are dissimilar to a study done by Kalarickal A<sup>15</sup> et al at Manipal shows actual mortality was 25.33% and predicted mortality with APACHE IV scoring was 17.4%. The results of our ICU scoring systems showed a discrimination compared with western studies as different ICU will have different SMR for any given scoring system depending on the standard of care of that particular ICU. But, the three ICU scoring models maybe more useful for Indian patients by calculating predicted mortality given by scoring systems for any given score when it is multiplied with SMR to get appropriate predicted mortality for particular setting without validation. As standards of care may improve or worsen with time depending on changes in equipment, technology, personnel and polices, SMR is likely to vary from time to time. Hence, periodic re-evaluation of scoring system must be done to obtain SMR periodically.

The strength of the study is that it is a prospective study in a well-equipped ICU and it evaluated all the three scoring systems simultaneously. It has shown that there is a linear relation between the score and mortality with the observed mortality increasing with increasing score.<sup>16</sup> It also has shown that the scoring systems grossly underestimate the mortality. The reason for higher than predicted mortality is attributable to the fact that the standards of ICU in our setup is not at par with international standards and indicates the need for more men and material. This perhaps reflects the different in standards between developing and developed



countries. Our study has established SMR for all the three scoring systems.

The three commonly used severity scoring systems compared in this study (Apache II, IV, SAPS III) was developed using large cohorts on critically-ill patients in American and European ICUs. However, selected Indian Hospital ICUs contributed in the development of SAPS III model.<sup>17</sup> As SAPS III<sup>18</sup> enrolled patients from different countries, it would be reasonable prediction from our study to perform well in external validation studies provided it is customised before application in Indian ICU setting.

The limitations of the study are that the number of patients in the study is small. In addition, our study evaluated predominantly medical patients and may not be applicable to other types of ICU patients.

### CONCLUSION

This prospective study of 115 ICU patients evaluated the three ICU scoring systems namely, APACHE II, APACHE IV and SAPS III in the medical ICU of a tertiary care corporate hospital attached to a medical college.

There is a linear correlation between the scores and observed mortality with increasing scores, the observed mortality progressively increases. This suggests that the scoring systems are valid and can accurately predict mortality in Indian setting also.

However, the observed mortality is significantly higher than predicted mortality (by a factor of 1.2, 3.61 and 1.4 for APACHE II, APACHE IV and SAPS III, respectively).

The SMR (standardised mortality ratio), the ratio between the observed mortality and mean predicted mortality for three scoring systems is as follows.

APACHE II- 1.2.

APACHE IV- 3.61.

SAPS III- 1.4.

After obtaining the score for individual patients, the mortality predicted by the scoring systems should be multiplied by the above factor. SAPS III admission scoring in predicting mortality risk stands good as it is recorded within one hour of ICU admission and other scoring system may be influenced by treatment effect.

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