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RESEARCH ARTICLE

# VALUE OF SEVERITY OF ILLNESS SCORING SYSTEM IN PREDICTING MORTALITY IN ELDERLY PATIENTS ADMITTED TO AN EGYPTIAN GERIATRIC INTENSIVE CARE UNIT

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## ABSTRACT

**Objective**: To assess the performance of 3 severity of illness scoring systems (Acute Physiology and Chronic Health Evaluation II (APACHE II), Simplified Acute Physiology Score II (SAPS II) and Mortality probability model II on admission (MPM 0) and after 24h of admission (MPM II)) in Egyptian critically ill patients.

**Material and method**: A prospective cohort study was conducted in a medical geriatric Intensive Care Unit, in a university hospital, Cairo, Egypt. We included 140 elderly patients (60 years and above)

Probabilities of hospital death for patients were estimated by applying the 3 severity of illness scoring system and compared with observed outcomes. The overall goodness-of-fit of the three models was assessed.

**Results:** The hospital death rate was under estimated by the 3 severity of illness scoring system. The difference in estimated mortality rate among survivors and non-survivors was significantly different for the 3 scoring system.

Regarding calibration, assessed by the Lemeshow±Hosmer chi-square statistic, showed that the MPM II had the best calibration (p=0.92) and the APACH II (p=0.64) and MPM 0 (p=0.56) had good calibration, while the SAPS II had the worst calibration (p =0.07), that is they all have accepted calibration but with varying degrees of accuracy

While discrimination using the ROC( receiver operating characteristic ) the SAPS II, MPM 0 and the MPM II showed good discriminative power as their ROC was 0.78, 0.79, 0.76 respectively, and the best for MPM 0 (ROC=0.79), while the APACHE II had moderate discriminative power as the ROC was o.67, that the 3 models had good to moderate discriminative power

**Conclusion:** we can conclude that all the 3 scoring system (APACH II, SAPS II, MPM (0, II)) can be used to predict mortality in critically ill elderly patients, and that they had accepted degree of discrimination and calibration in elderly ICU patients.

Hospital mortality was higher than predicted for all 3 models, so it is important to note that a patient with low mortality prediction scores can die in his ICU admission period, that is to say low severity scores cannot guarantee against suspected mortality.

In order to improve performance of these models may be alternative mortality prediction approaches might be needed to customize the models according to the geriatric Egyptian ICU patients.



## INTRODUCTION

In almost every country around the world, the proportion of elderly people (60 years and above) is growing faster than any other age group, and by 2050 the elderly population of the world will exceed that of the young for the first time in history (United Nations, 2001).

This demographic revolution has also affected the Egyptian population, in 2011 in Egypt the elderly people represented 7.3% of the population and this number is expected to rise to 11.6% by 2030 (CAPMAS, 2012).

With this increase, there is an expected dramatic increase in the prevalence of age – related diseases, so an increasingly old and ill population will require treatment in ICUs more frequently

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and their management will be a serious challenge to the health care providers. In the United States, those aged 65 years or older constitute about 50% of ICU admissions, this percentage will grow with the aging of the population (Milbrandt *et al.*, 2009). While also advanced age is associated with increased mortality in intensive care unit (ICU) patients (Wood and Ely 2003). In 2011 the mortality of elderly citizens in Egypt (60 years and above) represented 57.8% of the total mortality (CAPMAS, 2012).

So, an improved ability to predict outcome in elderly is of great assistance to the health care providers, such information can lead to changes in ICU discharge and admission decisions that will optimize the use of ICU facilities, enhance communication between patients, their families and physicians and also to control health care costs.

This lead to the development of several scoring systems, such models were constructed for general use in heterogeneous ICU populations and have not often been used to study risk prediction in elderly patients (Khouli *et al.*, 2011) while also, most studies that applied the prognostic models on elderly were in western countries, while few studies were done in developing countries, and little is known about the value of prognostic scoring systems on elderly admitted to Egyptian ICUs, Egypt, an African Arab country where geographic, cultural values and socio-economic standards differ from those in Western countries.

So, the aim of this study is to assess the Value of severity of illness scoring systems\ in predicting mortality among elderly patients admitted to an Egyptian geriatric intensive care unit.

## SUBJECTS AND METHODS

A prospective study was conducted in medical Intensive Care Units (geriatric ICU), Ain Shams University hospital, Cairo, Egypt, for about 9 months.

A 9 bed geriatric ICU (admits elderly 60 years and above), 24 hrs physicians staffing of the ICU is; 1 junior resident (who has worked there for >6m-<12months), 1 senior resident (who has worked there for>12 m), an assistant lecturer and a professional consultant. 24 hrs nursing staff is 3 per shift.

Patients were admitted either from the emergency unit or from other departments.

The study was approved by the scientific board of Geriatrics and Gerontology department, Faculty of Medicine, Ain Shams University

### *Inclusion and exclusion criteria*

We included 140 elderly patients (60 years and above) admitted to geriatric ICU with acute medical illness, we excluded those patients admitted to ICU for postoperative monitoring and post-traumatic and surgical patients.

### *Data collection*

The data was collected by an expert ICU physician and included demographic and ICU related parameters;

1. Demographic parameters as age, gender, complete medical history and assessment of co-morbidities and the current state at ICU admission
2. ICU parameters; Physical examination and recording of vital data on admission ,assessment of consciousness level by the Glasgow Coma Scale and recording of the worst parameters, clinical and laboratory data required for determination of the severity of illness and survival status (death or discharge from the ICU),during first 24 hours of admission
3. Severity of illness scoring systems:
   - APACHE II (The acute physiology and chronic health evaluation II ) (Knaus *et al.*, 1985)
   - SAPS II (Simplified acute physiology score II) (Le Gall *et al.*, 1993)
   - MPM II (Mortality probability model II on admission (MPM 0) and after 24h of admission (MPM II)) (Lemeshow and Le Gall 1994)

   Online calculation of the predicted mortality where done at the official website of (Société Française d'Anesthésie et de Réanimationdds): http://www.sfar.org
4. Establishment of end point of each patient (either discharge or death). The outcome measure was ICU mortality. Length of ICU stay was assessed as the number of days from admission to the ICU to discharge from the ICU. If a patient was readmitted to the ICU during the same hospitalization, only data from the first admission was taken.

Scoring systems used in critically ill patients are scores that assess disease severity on admission and is used to predict outcome (Vincent and Moreno 2010) and also they provide a mechanism to assess ICU performance by comparing actual outcomes in a given population to the outcomes observed in the reference population used to develop the prediction algorithms (Michael *et al.*, 2012)

### *Severity of illness scoring systems done to the patients in this study*

APACHE II (The acute physiology and chronic health evaluation II). In 1985, the original model was revised and simplified to create APACHE II (Knaus *et al.*, 1995), now the world's most widely used severity of illness score. In APACHE II, there are 12 physiological variables. The effects of age and chronic health status are incorporated directly into the model, weighted according to their relative impact, to give a single score with a maximum of 71. The worst value recorded during the first 24 hours of a patient's admission to the ICU is used for each physiological variable. The principal diagnosis leading to ICU admission is added as a category weight so that the predicted mortality is computed based on the patient's APACHE II score and their principal diagnosis at admission (Knaus *et al.*, 1995).

SAPS II (Simplified acute physiology score II) (Le Gall *et al*., 1993).

The SAPS II was based upon data from 8500 patients and was validated on a sample of 4,500 patients (Le Gall *et al*., 1993) . It has excellent discrimination and calibration (Castella *et al*., 1995).

The SAPS II is the most widely used version. It calculates a severity score using the worst values measured during the initial 24 hours in the ICU for 17 variables, several of the variables -as AIDS, metastatic cancer, hematological malignancy- are dichotomous, meaning that they are either present or absent. The others are continuous variables that have been made categorical by assigning points to ranges of values (Le Gall *et al*., 1993). Higher severity scores indicate more severe illness. The SAPS II can be entered into a mathematical formula, which predicts hospital mortality (Kelley Mark *et al*., 2011).

The APACHE II and SAPS II systems can be used to calculate the individual risk of hospital death by converting the score into probability of death using logistic regression

3- MPM II (Mortality Prediction Model II) on admission (MPM II 0) and after 24 hours from admission (MPM II)

A severity score is calculated from 15 variables, as assessed at the time of ICU admission. Except for age, all of the variables are dichotomous. In other words, they are either present or absent. The final score is entered into a mathematical formula whose solution provides the predicted mortality (Kelley Mark *et al*., 2011)**.**

The MPM II severity score that is measured on admission (MPM II 0) can be refined after 24 hours (MPM II) by updating seven of the admission variables and adding six variables. The updated admission variables include coma, intracranial mass effect, mechanical ventilation, metastatic disease, cirrhosis, type of admission, and patient age.

The additional variables include the following; Creatinine>2 mg/dL, Urine output <150 mL over eight hours, Confirmed infection, Vasoactive medications for ≥1 hour, Arterial oxygen tension (PaO2) <60 mmHg, Prothrombin time greater than the sum of the standard plus three seconds (Lemeshow and Le Gall, 1994)

***Statistical Analyses***

The mean and SD were calculated for the data. Descriptive statistics for continuous variables were expressed as mean ±SD To assess performance, researchers generally focus on discrimination and calibration.

Severity of illness scoring systems that has high discrimination is able to accurately identify the patients at highest risk for mortality.

An the area under the receiver operating characteristic curve (ROC) of 0.5 is no better than chance, whereas values. 0.7, 0.8, and 0.9 are considered acceptable, excellent, and outstanding, respectively (Hosmer and Lemeshow, 2000)

To measure calibration, which examines how well actual outcomes match their predicted incidence, the Hosmer-Lemeshow C statistic often is used, Calibration was considered good when there was a low $\chi 2$ value and a high p value (>0.05)( Lemeshow and Hosmer, 1982). Calibration also has relevance across different ICU types, admission diagnoses, and geographic regions.

The ability of predictive systems to provide risk estimations corresponding to actual mortality rates (calibration) and the ability to correctly classify survivors and nonsurvivors according to estimated probability of death (discrimination) were measured for the APACHE II, SAPS II and MPM (0,II) scoring systems.

## RESULTS

Demographic characteristics of the studied group shows that mean age was (70.0± 8.14), there was no significant difference between mean age of survivors and non survivors. 66 patients were males (47%) and 74 (52.8%) were females. There was no significant difference between number of co-morbidities among the survivor and non-survivor groups, also there was no difference between the two groups regarding the length of hospital stay as shown in table (1).

The actual mortality was 59.29%, the APACHE II's predicted risk of hospital mortality was 42 % compared to 40.8% for SAPS II and 46.3% for MPM 0 while for MPM II was 42.5% as shown in table(1).

The difference in estimated mortality rate among survivors and non-survivors was significantly different for the 4 mortality predictor scales.

There was significant difference between the mean of GCS of the survivors (12.72±3.904) compared to the mean of the non-survivors (9.51±5.220) as shown in table (1).

**Table1** Characteristics of elderly patients and comparison of subgroups according to survival status

| | All patients 140 (100%) | Survivors 57 (40.71%) | Non survivors 83 (59.29%) | p-value |
|---|---|---|---|---|
| Age | 70.0± 8.14 | 71.39±8.772 | 69.10±7.589 | 0.102 |
| Number of co-morbidities | | 4.561±1.842 | 4.867±1.552 | 0.290 |
| Length of ICU stay | 9.8 ± 9.2 | 8.75±7.586 | 10.61±10.096 | 0.240 |
| Glasgow coma scale | 10.81±4.97 | 12.72±3.904 | 9.51±5.220 | 0.000* |
| APACHE II (%) | 42.03±21.57 | 34.175±17.947 | 47.418±22.278 | <0.001* |
| SAPS II (%) | 40.81±26.96 | 25.296±18.395 | 51.467±26.808 | <0.001* |
| MPM 0 (%) | 46.31±26.13 | 30.173±17.825 | 57.189±25.272 | <0.001* |
| MPM II(%) | 42.47±27.08 | 28.408±19.968 | 52.125±27.188 | <0.001* |

ICU= intensive care unit, APACHE II= The acute physiology and chronic health evaluation II, SAPS II= Simplified acute physiology score II, MPM 0= Mortality probability model II on admission, MPM II= Mortality probability model II after 24h of admission.

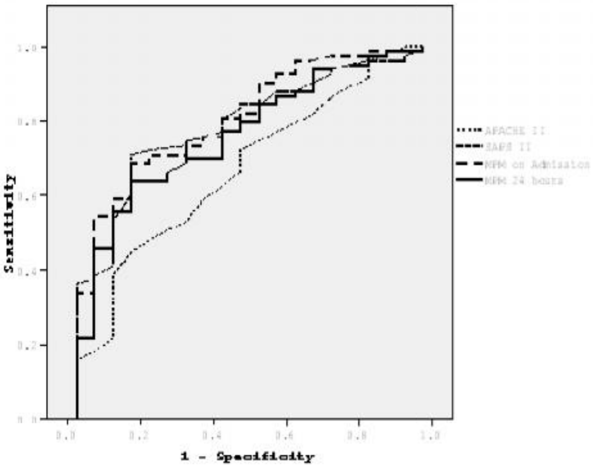
Calibration of the scoring system was done using the Hosmer Lemeshow statistics, the calculated value was; 6.017 (p=0.64) for APACHE II, 14.05 (p=0.07) for SAPS II, 6.67 (p=0.56) for MPM 0 while for MPM 24 was 3.17 (p=0.92), so, MPM 24 has better calibration than the APACHE II, then MPM 0 and the worst calibration as done by the Hosmer Lemeshow statistics was for the SAPS II.(The calibration is considered good if the Hosmer-Lemeshow statistic *p* value is >.05) as shown in table (2).

**Table 2** Logistic regression/odds ratio, calibration (HL), Discrimination (ROC) for APACHE II, SAPA II, MPM 0, MPM II and Glasgow coma scale (GCS);

| Scoring model | Logistic regression | | HL test | | ROC-Analysis | |
|---|---|---|---|---|---|---|
| | OR | 95%-CI | X | P-value | AUC | 95%-CI |
| APACHE II | 1.000 | 0.967-1.033 | 6.017 | 0.645 | 0.670 | 0.580– 0.759 |
| SAPS II | 0.977 | 0.945-1.010 | 14.05 | 0.070 | 0.782 | 0.705– 0.859 |
| MPM 0 | 0.962 | 0.933-0.992 | 6.679 | 0.562 | 0.795 | 0.721– 0.868 |
| MPMII | 0.995 | 0.965-1.026 | 3.173 | 0.923 | 0.758 | 0.678– 0.837 |
| GCS | 0.959 | 0.841- 1.094 | | | | |

95%-CI: 95%-confidence interval, ROC: receiver operating characteristic, AUC: Area under ROC curve, HL: Hosmer-Lemeshow, OR: Odds ratio for risk of mortality. APACHE II= The acute physiology and chronic health evaluation II, SAPS II= Simplified acute physiology score II, MPM 0= Mortality probability model II on admission, MPM II= Mortality probability model II after 24h of admission, GCS= Glasgow coma scale

Receiver operating characteristic curves for the APACHE II, SAPS II, MPM 0 and MPM II.




APACHE II= The acute physiology and chronic health evaluation II, SAPS II= Simplified acute physiology score II, MPM 0= Mortality probability model II on admission, MPM II= Mortality probability model II after 24h of admission.

Regarding the ROC: receiver operating characteristic; the SAPS II, MPM 0 and the MPM 24 showed good discriminative power as their AUC was 0.78, 0.79, 0.76 respectively, and the best for MPM 0 (AUC=0.79), while the APACHE II had moderate discriminative power as the AUC was o.67, as shown in table (2) and as shown by the ROC curves, discriminative power is important because it shows how many patients are correctly classified as survivors and nonsurvivors by the mode.

## DISCUSSION

Most severity of illness scoring systems were developed from large heterogeneous cohorts of medical and surgical patients in American and European countries, so, it was important to evaluate their predictive accuracy among Egyptian elderly (from an African country) with a different disease spectrum and in smaller settings, before applying them to make quality of care assessments and to predict mortality in this different group of patients.

This study assessed the predictive power of 3 commonly used severity of illness scoring systems, the APACHE II, SAPS II and the MPM (0 and II) in predicting mortality in a small heterogeneous population of Egyptian elderly admitted to geriatric medical ICU with multisystem organ dysfunction.

The actual mortality for our patients was 59.29%, it is known that, morbidity and mortality in elderly patients admitted to the ICU are higher than in younger patients (Vosylius *et al.*, 2005). It was found that the effect of age on prognosis depended on factors such as diagnosis at admission, severity of illness, co-morbidity and complications in ICU, which significantly influence outcome (Walther and Jonasson, 2004),(Bo *et al.*, 2003), (Djaiani and Ridley, 1997).

The actual mortality for our patients was 59.29%while the predicted mortalities for the 4 mortality prediction scale were 42%, 40.8%, 46.3% and 42.5% for the APACHE II, SAPSII, MPM 0 and the MPM II respectively, that is to say that all the 3 scales provided an under-prediction of mortality, but the MPM 0 provided the highest predicted risk (46.3%).

The 3 severity of illness scoring systems predicted death rates were higher in non-survivors than in survivors.

This was also found in other studies as APACHE II score and SAPS II were significantly higher in patients who died than in those who survived (Schönhofer *et al.*, 2004), (Sakr *et al.*, 2008), (Mbongo *et al.*, 2009), (Quach *et al.*, 2009)

The ability of scoring systems to provide risk estimations corresponding to actual mortality rates (calibration) and the ability to correctly classify survivors and non-survivors according to estimated probability of death (discrimination) were measured for APACHE II , MPM (0and II) and SAPS II scoring systems.

Comparison of the APACHE II, SAPS II and MPM (0and II) in our elderly patients showed that the 3 models had good to moderate discriminative power, with the MPM 0 having the best discriminative power among the other models , that is the 3 models showed how many patients were correctly classified as survivors and non-survivors by the model.

Some studies had found that APACH II, SAPS II, MPM II had accepted discrimination in elderly (Sikka *et al.*, 2000), (Qiao *et al.*, 2012).

Discriminative power of these tests showed better performance in younger age compared to elderly group as shown by Sikka *et al* (2000),

Murpy –flinks *et al* (1996) found that increasing the percentage of elderly patients, especially those exceeding the age of 75, decreases discrimination and that scales that accurately predict mortality involved cases who were younger and less ill.

Regarding calibration, goodness-of-fit, assessed by the Lemeshow±Hosmer chi-square statistic, that showed how well the predicted outcomes matched with the observed outcomes throughout the range of risk, showed that the MPM II had the best calibration and the APACH II and MPM 0 had good calibration, while the SAPS II had the worst calibration (p =0.07), that is they all have accepted calibration but with varying degrees of accuracy.

Some studies showed that the APACHE II had good calibration in critically ill elderly and that the scores closely fit the observed outcomes (Qiao *et al.*, 2012), while other studies (Sikka *et al.*, 2000) showed that calibration was insufficient for both APACE II and SAPS II in the elderly cohort, as hospital mortality was lower than the predicted mortality for both scales.

That is to say that in our study discrimination and calibration were accepted for all the 3 scales, but the under-prediction of mortality by the 3 scales has different explanations.

One is the fact that these scales are based on data obtained during the first 24 hours after ICU admission and that they do not take into account complications that may develop during ICU stay.

Studies showed that the accuracy of the severity of illness scoring systems were based on data from the first 24 hours after ICU admission is accepted only in patients who stay in the ICU for a short period of time (Lemeshow *et al.*, 1994). After this period has passed discriminative power decreases, most probably due to excess risk of death with increased period of ICU stay.

Of course elderly patients are at greater risk for ICU complication especially with prolonged ICU stay, as elderly may be at greater risk for nosocomial infections and subsequent mortality compared with younger patients (Gastmeier *et al.*, 2007). Also, delirium is common in critically ill elderly patients both during acute illness and after discharge and this is associated with increased mortality, length of stay, and cost, as well elderly are more prone to iatrogenic complications from invasive monitoring, prolonged bed/chair rest, sleep deprivation, increased hospital length of stay, and more restrictive visiting hours for families (Mercier *et al.*, 2010), (Pisani *et al.*, 2010). All of these risks may lead to increased morbidity and mortality (Herridge, 2009) (Girard *et al.*, 2010) From this we can conclude that a scoring system that allows regular follow up of organ function is needed, and not only during the first 24 hours of admission, especially in elderly patients, and this was found in a study done by Qiao *et al* (2012) they found that SOFA Max score and the ΔSOFA scores (ΔSOFA score was defined as the difference between the SOFA max and SOFA initial scores) had better calibration and discrimination in critically ill elderly than APACH II scores , they stated that the ΔSOFA score reflected the degree of dysfunction or failure developing during the ICU stay and could be used to monitor daily progress and to provide an objective evaluation of treatment responses.

Another explanation for this under prediction of these models can be the quality of care, difference between the predicted and observed outcomes is considered to indicate better or worse than average quality of care , (Vosylius *et al.*, 2015) differences regarding the quality of care in our ICU with respect to that in the ICUs used in the development of the severity of illness scoring systems can be but into account , but not as the only cause for this under prediction of mortality all the above mentioned explanations should be put into consideration.

The interpretation of our results can only be done with extreme caution, as the relatively small number of patients is a major drawback, but this can be considered as a pilot study to assess the value of severity of illness scoring systems in predicting mortality in a group of elderly Egyptian patients admitted to a geriatric ICU in Egypt, as it is the first study to our knowledge done on Egyptian elderly ICU patients, further studies with larger sample size are needed.

But, also from this study we can conclude that all the 3 severity of illness scoring systems (APACH II, SAPS II, MPM (0, II)) can be used to predict mortality in critically ill elderly patients, and that they had accepted degree of discrimination and calibration in elderly ICU patients,

But it is important to note that a patient with low mortality prediction scores can die in his ICU admission period, that is to say a low severity scores cannot guarantee against suspected mortality. In order to improve performance of these scales, may be alternative mortality prediction approaches might be needed to customize the models according to the geriatric Egyptian ICU patients, regional customization, or to develop specialized models targeted to this group of patients, putting into consideration the points discussed in this study.

Validation of these severity of illness scoring systems among elderly ICU patients is essential. Because there is a great variation in clinical and other patient characteristics among such a population, as a more accurate prognosis predictions in critically ill elderly patients may help to decrease morbidity, improve therapeutic strategies and increase patients' quality of life.

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