Original Article

Outcomes Prediction in Critically Ill Elderly Patients Using MPM0-III and SAPS 3 scores.

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Abstract

Background:

As the global population ages, the demand for accurate prognostic tools for this vulnerable demographic has intensified.

Objective:

Evaluating the prognostic ability of the Mortality Prediction Model (MPM0-III) and Simplified Acute Physiologic Score (SAPS 3) scoring systems in severely ill elderly patients admitted to Geriatrics ICU at Ahmed Shawki Hospital, Ain Shams University Hospitals**.**

Methods:

A 6-month prospective observational cohort research included 106 old patients of both sexes admitted to Geriatrics ICU at Ahmed Shawki Hospital, Ain Shams University Hospitals. The following information was recorded: demographics, history, physical examination, vital signs, conscious level assessment, worst parameters of clinical and laboratory data needed to determine the severity of illness, and survival status (death or release from the ICU). This information was collected both at the time of admission and during the first 72 hours of the patient's stay in the hospital. RNSH-ICU calculators were used to formulate the Mortality Probability Model Score at 24, 48, and 72 hours after admission. MDCalc was used to calculate the Simplified Acute Physiology Score 3 on admission.

Results:

Comparison between survivors and non-survivors as regards MPM0-III and SAPS 3 predictive mortality rates revealed a statistically significant higher scores (in both) among the non-survivors (P<0.001). MPM24 had the best calibration while MPM72 showed the best AUC. When the odds of mortality were estimated utilising MPM0-III and SAPS 3 scores by logistic regression analysis, both were found highly significant (P<0.001).

Conclusion:

With an acceptable degree of discrimination and calibration, the two severity of illness scoring systems (MPM0-III and SAPS 3) performed well and can be used to predict death in elderly critically ill patients.

Key words: MPM0-III, SAPS 3, mortality prediction, geriatrics ICU

INTRODUCTION

As the global population continues to age, the demand for specialized medical care for older adults has never been more pressing. The field of geriatric medicine has evolved to address the unique healthcare needs of the elderly, and within this specialty, the Geriatric Intensive Care Unit (ICU) plays a vital role ***(Flaherty et al., 2022).***

Elderly patients undergo a range of physiological changes such as decreased organ function, altered drug metabolism, and compromised immune responses. These changes impact diagnosis, treatment, and recovery, necessitating specialized interventions and personalized care plans. Elderly patients are particularly susceptible to

adverse events, including falls, infections, and medication-related complications. Coexisting chronic conditions, polypharmacy, and cognitive impairments contribute to the complexity of medical management in the elderly ***(Geen et al., 2021).***

In ICU patients, the multiple organ dysfunction syndrome—which is defined as the emergence of a progressive and possibly reversible physiologic derangement involving two or more organ systems unrelated to the primary disorder—is frequently a sign of impending death, particularly in the elderly subset. Over the past few decades, a variety of risk prediction scores have been created and verified ***(Govil & Pal, 2021).***

Even with the deployment of expensive, high-tech equipment, intensive care unit death rates are still high. The prediction of ICU outcomes in terms of morbidity and mortality is an essential part of care across the continent due to the severe shortage of experts, resources, and data, which exacerbates the burden of illnesses. Mortality prediction models are employed not only for outcome prediction but also as instruments for analytical decision-making and quality improvement. These mortality prediction models aid in estimating the severity of the disease, predicting the course of the sickness, and allocating resources ***(Keegan et al., 2011).***

The Mortality Prediction Model (MPM0-III) and the Simplified Acute Physiologic Score (SAPS 3) are two of the main predictive scoring systems used to predict mortality in general ICU patients ***(Nathanson et al., 2007; Moreno et al., 2005)***.

OBJECTIVE

To evaluate the MPM0-III and SAPS 3 scoring systems' predictive ability of hospital mortality in critically ill elderly patients admitted to Geriatrics ICU at Ahmed Shawki Hospital, Ain Shams University Hospitals.

METHODS

This was a prospective observational cohort study. It involved 106 elderly patients from both sexes aged 60 years and more who were admitted to Geriatrics ICU at Ahmed Shawki Hospital, Ain Shams University Hospitals during a period of 6 months from March 2023 to August 2023 with acute medical illness. During the same hospitalization, only data from the first admission was taken.

Demographic data (age, gender, complete medical history, and assessment of co-morbidities using Charlson Comorbidity Index), ICU related parameters including physical examination, vital data on admission, assessment of conscious level by the Glasgow Coma Scale, the worst parameters of clinical and laboratory data required for determination of the severity of illness and survival status (death or discharge from the ICU), during first 72 hours of admission were recorded. Mortality Probability Model Score (MPM0-III) by using RNSH-ICU calculators on 24, 48 and 72 hours and Simplified Acute Physiology Score (SAPS 3) by using MDCalc Medical calculator on admission were estimated. MPM0-III and SAPS 3 offer a comprehensive collection of factors to assess a patient's state, with 16 and 20 variables, respectively. Vital signs and other physiological measures, laboratory results, age, previous health status, use of major therapeutic options before ICU admission and the source of admission are some examples of these factors.

Establishment of end point of each patient and assessment of outcomes included: length of stay (LOS) was calculated from hospital admission to hospital discharge, length of ICU stay was assessed as the number of days from admission to discharge from the ICU, site of discharge either to ward, home, nursing home or others, and date and location of death. After being discharged from the hospital, patients were contacted by phone to check in with their family members the status of the patients.

Patients who died within the first 24 hours of ICU admission and those who were readmitted twice or more within the period of study were excluded from the study.

The research was approval by the Ethical Committee of the Faculty of Medicine, Ain Shams University (FMASU MS 523/2022) and by the Research Review Board of the

Geriatrics and Gerontology Department, Faculty of Medicine, Ain Shams University. Consent was taken from the administration in order to proceed. There were adequate provisions to maintain the privacy of participants and the confidentiality of data by collecting the participants' data in a file with a specific hospital number.

The collected data was revised, coded, tabulated, and introduced to a PC using Statistical Package for Social Science (SPSS 28) (IBM corp. Released 2021. IBM SPSS Statistics for Windows, Version 28.0. Armonk, NY). Data was presented, and suitable analysis was done according to the type of data obtained for each parameter. Numerical values were expressed as mean and standard deviation or median and range. Non-numerical data were presented as frequency and percentage. Student t-test / Mann-Whitney test was used to assess the statistical significance of the difference of a parametric / non-parametric variable (respectively) between two study groups. Chi-Square test was used to examine the relationship between two categorical variables. Logistic multiple regression analysis was used to predict the relationship between a scalar dependent variable and two or more predictor variables (independent variables). The Hosmer–Lemeshow goodness-of-fit C statistic was used to evaluate calibration, and the standardised mortality rate (SMR) was used to evaluate the overall accuracy of mortality forecasts. Receiver operating characteristic curves (ROC), which compute the area under the curve, were used to assess discrimination (AUC). A statistical difference was deemed significant when $P<0.05$ and highly significant when $P<0.001$.

RESULTS

The present study revealed that out of the 106 patients, 58 (54.7%) were females and 48 (45.3%) were males. The mean age was 74.8±8.34 years. At the end of study period and according to their prognosis, 54 (50.95%) patients were survivors and 52 (49.05%) were non-survivors. Ninety-one (91) patients were admitted from Emergency Room (ER) (85.8%), 13 patients from ward (12.3%) and 2 patients transferred from other ICUs (data are not shown in tables). All were medical patients. Comparison between survivors and non-survivors in all demographic data revealed no significant differences ($P>0.05$) (Table 1). Comparison of comorbidities along with baseline laboratory data between survivors and non-survivors is shown in table (2).

Table (1): Comparison between survivors and non-survivors regarding demographic data

	All Patients (n=106)	Survivors (n=54)	Non-survivors (n=52)	P-value
	(Mean±SD)	(Mean±SD)	(Mean±SD)	
Age (years) (Range=60-98)	74.8±8.34	72.5±7.3	77.1±8.8	0.22
	n (%)	n (%)	n (%)	P-value
Sex				
Male	48 (45.3%)	25 (52.1%)	23 (47.9%)	0.83
Female	58 (54.7%)	29 (50.0%)	29 (50.0%)	
Marital status				
Single	2 (1.9%)	0 (0%)	2 (100%)	0.35
Married	39 (36.8)	21(53.8%)	18 (46.2%)	
Widow	64 (60.4%)	33 (51.6%)	31 (48.4%)	
Divorced	1 (0.9%)	0 (0.0%)	1 (100%)	
Smoking status				
Non-Smokers	81 (76.4%)	45 (55.6%)	36 (44.4%)	0.087
Smokers	25 (23.6%)	9 (36%)	16 (64%)	

Table (2): Comparison between survivors and non-survivors regarding their comorbidities and baseline laboratory data

Comorbidities		All Patients (n=106)	Survivors (n=54)	Non-survivors (n=52)	P-value
		n (%)	n (%)	n (%)	
Cardiac disease		104 (98.1%)	53 (51%)	51(49%)	0.16
Hypertension		68 (64.2%)	40 (58.8%)	28 (41.2%)	0.03
Diabetes mellitus		52 (49.1%)	29 (55.8%)	23 (44.2%)	0.33
Dementia		38 (35.8%)	21 (55.3%)	17 (44.7%)	0.50
Neurological diseases		34 (32%)	23 (67.6%)	11 (32.4%)	0.01
Renal disease		23 (21.7%)	12 (52.2%)	11 (47.8%)	0.89
Pulmonary diseases		23 (21.7%)	6 (26%)	17 (74%)	0.04
Hepatic diseases		22 (20.8%)	11 (50.0%)	11 (50.0%)	0.92
Previous intensive care unit admission		33 (31.1%)	11 (33.3%)	22 (66.7%)	0.02
Charlson Comorbidity Index	<7	64 (60.4%)	34 (53.1%)	30 (56.9%)	0.58
	≥7	42 (39.6%)	20 (47.6%)	22 (52.4%)	
Laboratory investigations		(Mean±SD) / Median (25^{th}-75^{th} percentile)	(Mean±SD) / Median (25^{th}-75^{th} percentile)	(Mean±SD) / Median (25^{th}-75^{th} percentile)	
Total leucocytic count (10^9/L) (Range=1.0-24.8)		9.96±4.6	9.7±4.2	10.3±5.2	0.52
C-reactive protein (mg/dl) (Range=0.4-387)		61.7 (22-146)	34.5 (14-88.25)	103.5 (46-176.6)	0.001
Albumin (mg/dl) (Range=1.7-4.4)		3.1±0.06	3.3±0.54	2.9±0.6	0.001
Blood urea nitrogen (mg/dl) (Range=8-163)		37.5 (21-67.75)	30.5 (16.75-61.25)	49.5 (29.25-71.75)	0.011
Creatinine (mg/dl) (Range=0.2-9.5)		1.3 (0.98-2.53)	1.3 (0.9-2.5)	1.5 (1.0-3.05)	0.45
Prothrombin time (sec) (Range=11-43.2)		16.1±3.93	14.9±2.3	17.3±4.8	0.001
International normalised ratio (Range=1-4)		1.3±0.4	1.2±0.2	1.5±0.6	0.001

Table (3) showed the incidence of different diseases in both survivors and non-survivor groups. Out of 106 patients studied, 23 (21.7%) patients had respiratory diseases; 16 out of them had died with a significant difference between survivors and non-survivors (X^2=4.94, P=0.03, data not shown in the table). Thirteen patients (12.3%) had septic shock; 11 of them had died (84.6%) with also a highly significant difference between survivors and non-survivors (X^2=7.497, P=0.006, data not shown in the table).

Table (3): Comparison between survivors and non-survivors regarding cause of ICU admission

Cause of admission	All Patients (n=106)	Survivors (n=54)	Non-survivors (n=52)
	n (%)	n (%)	n (%)
RENAL (n=10 Patients)			
AKI	6 (5.7%)	6 (100%)	0 (0%)
Urosepsis	2 (1.9%)	2 (100%)	0 (0%)
Uremic encephalopathy	2 (1.9%)	0 (0%)	2 (100%)
Total	10 (9.4%)	8 (14.8%)	2 (3.8%)
CHEST (n=23 Patients)			

CAP	14 (13.2%)	5 (35.7%)	9 (64.3%)
HAP	2 (1.9%)	0 (0%)	2 (100%)
COPD exacerbation	1 (0.9%)	1 (100%)	0 (0%)
Aspiration Pneumonia	2 (1.9%)	0 (0%)	2 (100%)
Respiratory Distress	3 (2.8%)	1 (33.3%)	2 (66.7%)
Respiratory Failure	1 (0.9%)	0 (0%)	1 (100%)
Total	23 (21.7%)	7 (13%)	16 (30.8%)
CARDIOVASCULAR (n=5 Patients)			
Arrhythmia	1 (0.9%)	1 (100%)	0 (0%)
Decompensated HF	1 (0.9%)	1 (100%)	0 (0%)
NSTEMI	1 (0.9%)	0 (0%)	1 (100%)
Pulmonary edema	1 (0.9%)	0 (0%)	1 (100%)
Hypertensive Urgency	1 (0.9%)	1 (100%)	0 (0%)
Total	5 (4.7%)	3 (5.6%)	2 (3.8%)
NEUROLOGIC (n=11 Patients)			
Acute Stroke	9 (8.5%)	5 (55.6%)	4 (44.4%)
IVH	1 (0.9%)	0 (0%)	1 (100%)
Postictal Confusion	1 (0.9%)	1 (100%)	0 (0%)
Total	11 (10.4%)	6 (11.1%)	5 (9.3%)
SHOCK (n=17 Patients)			
Septic Shock	13 (12.3%)	2 (15.4%)	11 (84.6%)
Cardiogenic Shock	2 (1.9%)	0 (0%)	2 (100%)
Hypovolemic Shock	2 (1.9%)	2 (100%)	0 (0%)
Total	17 (16%)	4 (7.7%)	13 (24.1%)
HEPATIC (n=9 Patients)			
Hepatic encephalopathy	5 (4.7%)	1 (20%)	4 (80%)
Melena	1 (0.9%)	1 (100%)	0 (0%)
Hematemesis	3 (2.8%)	2 (66.7%)	1 (33.3%)
Total	9 (8.5%)	4 (7.4%)	5 (9.6%)
OTHER			
Sepsis	9 (8.5%)	5 (55.6%)	4 (44.4%)
Severe Anemia	2 (1.9%)	2 (100%)	0 (0%)
Hypoglycemic coma	1 (0.9%)	1 (100%)	0 (0%)

AKI: Acute Kidney Injury; CAP: Community Acquired Pneumonia; HAP: Hospital Acquired Pneumonia; COPD: Chronic obstructive pulmonary disease; HF: Heart failure; NSTEMI: Non-ST elevation myocardial infarction; IVH: Intraventricular hemorrhage

Table (4) showed that length of ICU stay was significantly longer in non-survivors (P=0.044), while length of post-ICU stay was significantly longer in survivors (P<0.001). Thirty-day mortality in ICU was recorded in 50 patients (47.1%), 42 of 50 patients had died in their first ICU admission and 8 of 50 patients had died in their second ICU admission. Two patients (1.9%) had died at home after hospital discharge (Table 5).

Table (4): Comparison between survivors and non-survivors regarding length of stay in ICU

Outcome Prediction	All Patients (n=106) Median (25^{th}-75^{th} percentile)	Survivors (n=54) Median (25th -75th percentile)	Non-survivors (n=52) Median (25^{th}-75^{th} percentile)	P-value
Total LOS days (Range=3-57)	12 (8-17)	15 (8-19)	11 (5-16)	0.049
Pre-ICU days (Range=0-11)	0 (0-1)	1 (0-2)	0 (0-1)	0.053
ICU days (Range=2-30)	7 (4-11.25)	6 (3-8.25)	8 (4.25-14.5)	0.044
Post-ICU days (Range=0-26)	2.5 (0-6)	5 (3-10)	0 (0-0)	0.001
	All Patients n (%)	Non-survivors n (%)		
ICU Mortality	50 (47.1%)	42 (84%) in 1^{st} ICU admission +	8 (16%) in 2^{nd} ICU admission (5 from ward+3 from palliative)	

ICU: Intensive Care Unit, LOS: Length of stay

Table (5): Fate and Incidence of patients who survived and discharged after their first ICU admission

Discharge to	All Patients (n=64) n (%)	Survivors (n=54) n (%)	Non-survivors (n=10) n (%)
Ward	45 (42.5%)	40 (88.9%)	5 (11.1%)
Palliative	13 (12.3%)	10 (76.9%)	3 (23.1%)
Home	6 (5.7%)	4 (66.7%)	2 (33.3%)*

* Patients who were discharged were followed up for one month through phone calls, 2 of them had died at home

Comparison between survivors and non-survivors regarding the predictive mortality of MPM0-III and SAPS 3 showed that both tools had statistically significant higher scores in the non-survivors (P<0.001) (Table 6).

Table (6): Comparison between survivors and non-survivors regarding different predictive mortality rate scores used in the study

Score examined	Survivors (n=54)	Non-survivors (n=52)	P-value
	Median (25^{th}-75^{th} percentile)	Median (25^{th}-75^{th} percentile)	
MPM24 PMR%	21.5 (12.4-32.9)	40.2 (27.0-56.5)	<0.001
MPM48 PMR%	24.6 (13.4-38.75)	50.6 (32.8-79.7)	<0.001
MPM72 PMR%	26.4 (15.5-38.4)	53.7 (37.6-83.5)	<0.001
SAPS 3 Score	60.5 (56-68)	72.5 (63-81.5)	<0.001
SAPS 3 PMR%	36.7 (27.6-52.5)	61.3 (41.9-75.6)	<0.001

MPM: Mortality Prediction Model; PMR: different predictive mortality rate; SAPS: Simplified Acute Physiologic Score

Comparing between the observed/actual mortality and the expected/predicted mortality, by using the standardized mortality rate (SMR), showed that no significant differences were found between the percentages of observed and the predicted mortality in the study by the tested models (P>0.05), except

for SAPS 3 score where the predicted mortality was significantly higher than the actual mortality (Table 7).

Table (7): Comparison between the observed and the predicted/expected mortality rates by the scores studied using standardized mortality rate equation

Score examined	Mortality			P-value
	Actual Mortality rate (Observed)	PMR (Expected) (Mean)	SMR(Observed/Expected) (95% CI)	
MPM24 PMR%	49.05	44.2	1.11 (0.8–1.42)	>0.05
MPM48 PMR%	49.05	54.8	0.89 (0.64-1.14)	>0.05
MPM72 PMR%	49.05	57.9	0.85 (0.61-1.09)	>0.05
SAPS 3 Score	49.05	73.7	0.67 (0.48-0.86)	<0.05
SAPS 3 PMR%	49.05	59.9	0.82 (0.59-1.05)	>0.05

CI: confidence interval; MPM: Mortality Prediction Model; PMR: different predictive mortality rate; SAPS: Simplified Acute Physiologic Score; SMR: Standard Mortality Rate

Calibration of the scoring systems was done using the Hosmer-Lemeshow (HL) statistics, where it is considered good if the Hosmer-Lemeshow statistic P value is >0.05. MPM24 had the best calibration followed by MPM72, SAPS 3 and then MPM48. Logistic regression analysis was also done to estimate odds of mortality using the different scores where they were highly significant for all (P<0.001) (Table 8).

Table (8): Logistic regression/odds ratio and calibration (HL), for MPM0-III and SAPS 3 scores for prediction of mortality in the ICU

Model	Logistic regression			Hosmer-Lemeshow test	
	Odds	95% CI	P-value	X^2	P-value
MPM24	1.057	1.029-1.085	<0.001	6.25	0.619
MPM48	1.061	1.035-1.088	<0.001	10.63	0.224
MPM72	1.064	1.036-1.092	<0.001	7.43	0.491
SAPS 3 score	1.112	1.060-1.167	<0.001	9.14	0.243
SAPS 3	1.059	1.033-1.086	<0.001	8.04	0.329

CI: confidence interval; MPM: Mortality Prediction Model; PMR: different predictive mortality rate; SAPS: Simplified Acute Physiologic Score; X^2 : Chi-Square test

The discriminative power of MPM24, MPM48, MPM72 and SAPS 3 scores showed fair to good results as their AUC were 0.769, 0.813, 0.828, 0.778 respectively (P<0.001 for all). The predictive mortality rate of MPM72 showed the best AUC (Table 9 and Figure 1).

Table (9): Diagnostic accuracy using Receiver Operating Characteristics (ROC) of different scores for the prediction of mortality in the ICU

	MPM24%	MPM48%	MPM72%	SAPS 3 score	SAPS 3%
Sensitivity	61.54	66.00	69.39	65.38	65.38
Specificity	79.63	86.79	86.00	77.78	77.78
Positive predictive value	74.4	82.5	82.9	73.9	73.9
Negative predictive value	68.3	73.0	74.1	70.0	70.0
Positive likelihood ratio	3.02	5.00	4.96	2.94	2.94
Negative likelihood ratio	0.48	0.39	0.36	0.45	0.45
Cutoff	>33.6	>43.3	>44.2	68	>52.5
Area under the curve	0.769	0.813	0.828	0.779	0.778
95% confidence interval	0.677-0.845	0.724-0.883	0.739-0.897	0.688-0.854	0.686-0.853
P-value	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001

MPM: Mortality Prediction Model; SAPS: Simplified Acute Physiologic Score

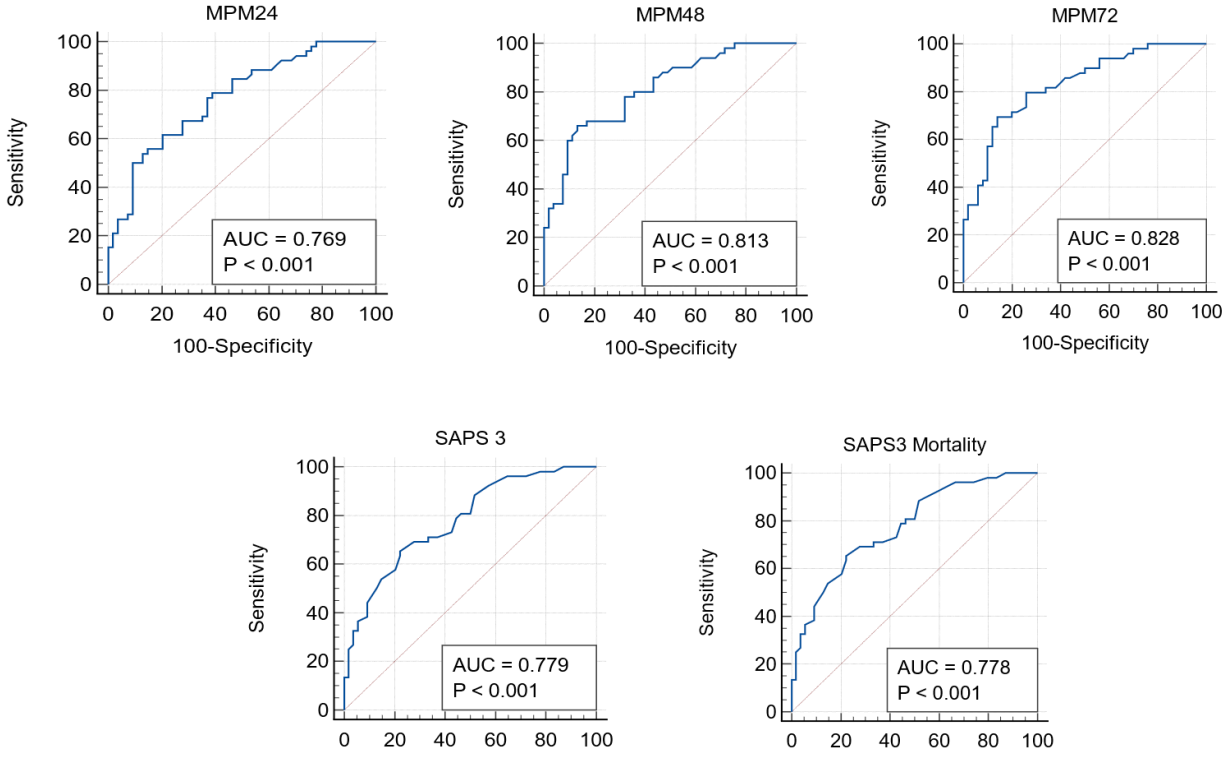

Figure (1): Diagnostic accuracy (ROC) of MPM24%, MPM48%, MPM72%, SAPS 3 score and SAPS 3% for prediction of mortality in the ICU

Multivariable logistic regression model was used to investigate the impacts of demographics, comorbidities, vitals, and labs on predicting mortality. Age, smoking, stroke, C-reactive protein, albumin, respiratory rate, diastolic blood pressure, LOS, previous ICU admission, mechanical ventilation and MPM72 PMR% were found to be significant independent predictors for mortality (Table 10).

Table (10): Multivariable logistic regression analysis for the prediction of mortality in the ICU

Variable	Odds ratio	95% CI	P-value
Demographic Data			
Age	1.0814	1.0256-1.1403	0.0038
Smoking	1.8647	1.0418-3.3378	0.0359
Comorbidities			
Stroke	0.3091	0.1215-0.7866	0.0138
Others			
Previous ICU admission	3.0676	1.2231-7.6941	0.0169
Length of stay	0.9423	0.8884-0.9995	0.0480
Mechanical ventilation	8.5944	1.0127-72.9368	0.0487
C-reactive protein	1.0077	1.0019-1.0136	0.0097
Albumin	0.4024	0.1843-0.8788	0.0224
Vitals			
Respiratory rate	1.1450	1.0576-1.2396	0.0008
Diastolic blood pressure	0.9534	0.9160-0.9924	0.0196
Scoring systems			
MPM72	1.0638	1.0362-1.0921	0.0001

CI: confidence interval; ICU: Intensive Care Unit; MPM: Mortality Prediction Model

DISCUSSION

The actual patient's mortality rate observed during this study period was 49.05% (52 out of 106 patients). The mean age of our patients was 74.8±8.34 years. Our result goes in line with previous studies done in Africa. A study done by our esteemed group ***Shaheen et al*** in ***(2016)*** reported a mortality rate of 59.29%. Mortality rates reported in Senegal 42.8%, Morocco 44.7%, Nigeria 52%, and Northwest Ethiopia 29.6% ***(Wade et al., 2012; Jihane et al., 2012; Owojuyigbe et al., 2016; Demass et al., 2023)***.

In Germany, ***Becker et al. (2015)*** reported a much lower mortality rate of 18.3% in a monocentric, retrospective observational study of all patients aged ≥90 years admitted to the ICU. Another recent European study done by ***Gonçalves-Pereira et al. (2023)*** also reported a mortality rate of patients admitted to Portuguese multipurpose ICUs; 18.5% in patients aged 65-80 years and 20.8% in patients >80 years.

In India, ***Miniksar and Özdemir (2021)*** reported a rate of mortality (81.7%) in patients aged 85 years or more and attributed that very high rate to the ICU type and the presence of terminal-stage-care patients. They also suggested that patient characteristics, ICU type, ICU admission criteria, strategies for end-of-life-care patients, and the experience of health-care personnel are important factors in terms of the rate of mortality.

Abuhasira et al. (2022) compared in their study the ICU mortality rates of older adults (≥80 years) from three large academic medical centers from three different developed countries across three continents (Israel, USA, and Australia). They found that ICU mortality were 40.08%, 13.86% and 20.62%, respectively. They stated that higher ICU bed capacity and more liberal ICU admission policies are associated with higher in-hospital survival of older adults.

We believe that the variations in the reported death rates between studies may be related to the clinical state of the patients upon admission, the accessibility of resources, infrastructure, personnel experience and training levels, and the ICU units' capacity.

When comparing patients with Charlson Comorbidity Index of <7 or those with an index of ≥7, our study revealed no significant difference between the groups of survivors and non-survivors. Compared with previous studies, our results conflict with some studies and are consistent with others. In contrast to our results ***Buntinx et al. (2002)*** found that mortality was significantly increased in patients with a moderate and even more in those with a high level of comorbidity. They concluded that Charlson's comorbidity index is a predictor of short-term mortality and recommended its use as a measure for introducing comorbidity as a covariable in longitudinal studies with a geriatric population. Recently, ***Zhang et al. (2023)*** found that in ICU patients with cardiac arrest, the age-adjusted Charlson's comorbidity index score was associated with in-hospital death and length of hospitalization stay, and they stated that it may be a valid indicator to predict mortality for those patients. In agreement with our finding, ***Winther-Jensen et al. (2016)*** found no correlation between the Charlson's comorbidity index score and the prognosis of cardiac arrest. Also, ***Poddar et al. (2023)*** in their study found that the comorbidity burden on Charlson's comorbidity index remained similar in old and very old patient groups and did not predict the outcome.

We propose that the reasons for the inconsistent study results may be caused by the sample size, the different demographic characteristics and selection of the populations studied, the different research methods used (prospective versus retrospective studies), and the methods used to calculate and propose the Charlson's comorbidity index score.

In our study we reported septic shock in 13 (12.3%) patients; 11 of them had died (84.6%) with a highly significant difference when comparison between survivors and non-

survivors (X^2=7.497, P=0.006). In agreement with our results, ***Angus et al. (2001)*** stated that in the elderly population, sepsis is a major cause of morbidity and mortality, with almost 60% of septic patients being over 65 years of age. They added that many risks including subtle clinical presentations, institutionalization, use of invasive devices, multiple medications, reduced renal function and poor nutritional status may contribute to the increased incidence of sepsis with age.

Guarino et al. (2023) stated that sepsis is still accompanied by an overall poor prognosis. However, they concluded in their work that a well-orchestrated treatment based on selected antimicrobics, fluids, oxygen, and, if necessary, vasoactive agents can improve patients' outcomes.

In our study, the observed mortality was 49.05%. The predicted mortality rates were as follows: 44.2%, 54.8%, 57.9% and 59.9% for MPM24, MPM48, MPM72 and SAPS 3. The mean and median scores of the MPM24, MPM48, MPM72 and SAPS 3 models were significantly higher in the non-survivor group than in the survivor group (P<0.001 for all scores). The calculated SMR at hospital discharge was 1.11, 0.89, 0.85, 0.82 (according to the predicted mortality of MPM24, MPM48, MPM72 and SAPS 3, respectively). We found that the observed number of deaths in the study was not statistically significantly different than the predicted number of deaths (P>0.05). So, we could conclude that the mortality was correctly predicted by all the scores used.

The actual mortality detected in ***Shaheen et al. (2016)*** work was 59.29%, and the predicted mortalities were 46.3%, 42.5% and 40.8%, for the MPM0, MPMII and SAPS II, respectively. They concluded that all the scales provided an under-prediction of mortality, but the MPM0 provided the highest predicted risk (46.3%). ***Moralez et al. (2017)*** estimated a SMR of 1.15 (95% CI, 1.13–1.18) for the MPM0-III and 1.00 (95% CI, 0.98–0.102) for the SAPS 3. They concluded that the SAPS 3 was accurate in predicting outcomes, supporting its use for performance evaluation and benchmarking in Brazilian ICUs. ***Korkmaz Toker et al. (2018)*** reported a SMR of 1.042 (95% CI, 0.824–1.301) according to SAPS 3 score in their cohort of patients with a mean age of 75.22±7.35 and they stated that mortality was correctly predicted with the SAPS 3 model (their actual mortality was 37% and the predicted mortality by SAPS 3 was 34.6%). ***Gonçalves-Pereira et al. (2023)*** reported a SMR of 0.70 according to SAPS II predicted mortality in a cohort of elderly patients aged ≥65-80 years (their actual mortality was 27.9% and the predicted mortality by SAPS 3 was 39.6%).

Accurate discrimination and calibration are two key characteristics that should be met by all predictive scoring systems ***(Kassam et al., 2021).***

According to our results, MPM24 showed the best calibration (P=0.619), however, the other scores also showed fair calibration (P=0.224 for MPM48, P=0.491 for MPM72 and P=0.329 for SAPS 3).

According to ***Shaheen et al. (2016)***, all the scores they utilised had accepted calibration, but with differing degrees of precision. They also indicated that the MPMII had the best calibration and the MPM0 had good calibration, while the SAPS II had the lowest calibration (P=0.07). ***Kassam et al. (2021)*** found that both SAPS 3 and MPM0-III were well calibrated amongst the critically ill patients admitted to their study setting. External validation studies have reported MPM0-III to have good calibration ***(Higgins et al., 2007; Higgins et al., 2009; Kuzniewicz et al., 2008; Lukoko et al., 2020)***. MPM0-III, however, was inaccurate in predicting mortality and has poor calibration in other studies ***(Costa eSilva et al., 2011; Maccariello et al., 2008; Moralez et al., 2017; Nassar Jr et al., 2012; Riviello et al., 2016; Soares et al., 2010).***

Poor calibration and a tendency to underestimate mortality were seen in several earlier investigations using the SAPS 3 ***(Costa eSilva et al., 2011; de Oliveira et al., 2013; Maccariello et al., 2008; Soares et al., 2010)***.

Conversely, the SAPS 3 tends to overestimate mortality with a reasonably low death rate in various other investigations (one of which included patients with acute coronary syndromes) ***(Metnitz et al., 2009; Nassar Jr et al., 2012; Nassar Jr et al., 2013; Poole et al., 2009)***. Despite being the first critical care prognostic model created using patient data from around the globe, SAPS III's performance in external validation trials was far from ideal, according to ***Nassar Jr et al. (2014)***. Discrimination was nearly usually very good or very excellent. They thought that SAPS III was a straightforward, easy-to-use, and dependable prognostic model that could be applied in clinical practice; however, it needed to be customized before being routinely employed in local contexts. It is possible that all general outcome prediction models fit this description. It appears that patients hospitalized with specific diagnoses should not be evaluated using SAPS III.

In the present study, all the scores showed highly significant abilities to discriminate between survivors and non-survivors (AUC for all scores showed P<0.001). The best sensitivity and specificity for predicting mortality was found by using MPM72 score at a cutoff >44.2, as well as it showed the best AUC (0.828).

MPM0-III has been externally validated in various ICUs in North America ***(Higgins et al., 2007; Higgins et al., 2009; Kuzniewicz et al., 2008)*** and has shown to have good discrimination which goes in line with our study finding. However, a study done at Aga Khan University Hospital, Nairobi, Kenya ***(Lukoko et al., 2020)*** and two public ICUs in Rwanda ***(Riviello et al., 2016)*** showed that MPM0-III have fair discrimination amongst their cohort. ***Higgins et al. (2007)*** stated that as with any model predicting ICU outcome, MPM0-III is intended to evaluate groups of patients and cannot be expected to precisely reflect acuity or predict outcome for individual patients. Thus, without taking into account a number of other factors such as patient and family preferences, risk factors that are not scored (such as malnutrition, bedridden status, patient's will to live), and the capabilities of the ICU, its physicians, and other healthcare providers, it would be inappropriate to use this or any similar model to plan treatment or admission to the ICU based on an estimated probability of death. ICU admission should not be prohibited even in cases with a low predicted chance of mortality, as it may be essential to secure survival through close monitoring and greater nursing attention.

Similarly, SAPS 3 has been externally evaluated in many intensive care units in Brazil ***(Nassar Jr et al., 2012)***, Austria ***(Metnitz et al., 2009)***, and Italy ***(Poole et al., 2009)***, and it has been confirmed to have high discriminatory capability amongst their cohort. In contrast to excellent discrimination (AUC = 0.91), ***Korkmaz Toker et al. (2018)*** found that SAPS 3 had a poor calibration (Hosmer–Lemeshow statistic, 25.254). Because of this primary benefit of SAPS 3, they argued, its anticipated level of mortality was greater than that of APACHE IV scores. They stated that scores recorded within the first 24 hours following ICU admission reflected standard care rather than actual clinical status. They concluded that although the SAPS 3 model has better discriminative power and a tendency to estimate mortality accurately, its lack in calibration makes it a less suitable model. ***Aggarwal et al. (2006)*** suggested that lack of acceptable calibration, regardless of good discrimination power, should result in rejection of a scoring system.

The first study on the effectiveness of predictive scoring models in a private context in Tanzania was conducted by ***Kassam et al.*** in ***(2021)***. They discovered that MPM0-III and SAPS 3 both had strong performance in their group. Based on their findings, death may be predicted with a sensitivity of 72% and specificity of 91% by using a SAPS 3 score more than 54, and with a sensitivity of 74% and specificity of 87% by using an MPM0-III score greater than 4. ***Zhu et al. (2022)*** found that the discrimination for 28-day mortality with the SAPS III (AUC) was 0.812 in their sepsis elderly patients with a

mean age of 65.97±15.77 years. They concluded that the SAPS 3 model showed the best ability to discriminate 28-day mortality compared with the other models used in their study (SIRS, SOFA, OASIS, and SAPS II models). In a study conducted by ***El-Kholy et al. (2022)***, the SOFA72 and MPM72 scores were compared for their ability to predict mortality in elderly ICU patients. The results showed that the MPM72 score had the highest specificity at 91% with an AUC of 0.81 at a cutoff value of 16, whereas the SOFA72 score had the highest sensitivity at 94.8% with an AUC of 0.94 at a cutoff value of 5.

The controversy between our results and that of others regarding the performance characteristics (discrimination and calibration) of the severity scoring systems used may be attributed to the effect of cohort composition, sampling bias, temporal bias (either in the process of care or in the case-mix), differences in healthcare provisions and end-of-life policies.

In the present study, age, smoking, stroke, previous ICU admission, length of hospital stays, mechanical ventilation, C-reactive protein, albumin, respiratory rate, diastolic blood pressure and MPM72 were proved to be significantly independent effector variables in predicting mortality. We think that if customization—of the predictive scoring methods employed in this study—is believed to fit our cohort of elderly Egyptian patients, then these characteristics ought to be given more weight and consideration.

In agreement with our results, age was addressed to have an influence on outcome in ICU patients by many studies ***(Beil et al., 2021; Brunker et al., 2023; de Rooij et al., 2005; Tang et al., 2003).*** In contrast to many of their younger colleagues, older adults carry complexity and fragility with them. Growing older increases the likelihood of unfavourable outcomes due to the prevalence of vulnerability characteristics such as frailty, disability, and multimorbidity. These variables can overlap, which increases the risk even further ***(Brummel & Ferrante, 2018)***. In the ***Giannasi et al. (2018)*** study, however, malnourishment and loss of functional independence were demonstrated to be powerful predictive markers, but chronological age was not found to related to in-hospital mortality. They concluded that judgments about the intensity of therapy may be made more effectively if these baseline parameters from the ICU admission were known.

According to several studies ***(Kassam et al., 2021; Moitra et al., 2016; Toptas et al., 2018),*** prolonged length of stay in the intensive care unit (LOS) and the transfer of patients from the general ward to the ICU were linked to increased odds of death among critically ill patients. It was also suggested that LOS in the ICU could be caused by the emergence of multi-systemic complications that required continuous organ support. These findings are consistent with our findings. Moreover, some contradicting findings indicating that LOS in the ICU is not an independent risk factor for in-hospital death have been published ***(Williams et al., 2010).*** In agreement with our results, studies have shown that age is independently associated with mortality in patients requiring mechanical ventilation and age was associated with longer duration of mechanical ventilation, ICU length of stay, and mortality ***(Bellani et al., 2016; Wang et al., 2020).***

According to a ***Zhang et al. (2022)*** meta-analysis research, smoking cigarettes is linked to a higher risk of death, particularly in older individuals (over 60) and those who currently smoke. After extending the follow-up time, they discovered that smoking has a significant and long-lasting impact on mortality. The high death rate among these patients, they concluded, ought to act as a deterrent for smoking cessation among at-risk groups as well as the patients themselves.

A recent study done by ***Ayrancı et al. (2021)*** agreed with our findings. They found that the concurrent high levels of C-reactive protein/albumin ratio values were more effective in predicting in-hospital mortality compared to a separate evaluation. Also, ***Şimşek et al. (2021)*** concluded this ratio may

be a significant predictor of mortality in elderly patients who were aged 80 years and over with non-ST elevation myocardial infarction.

The strength of this study is that it is a prospective observational one that allowed us to closely follow up patients. Another strength is that a large-scale, big data investigation was performed. However, it has some limitations that should be considered. Firstly, the study was conducted in a single center, which may limit generalizability of the findings. Secondly, the study only evaluated two commonly used severity of illness scoring systems, and other models were not included in the analysis. Thirdly, the study only focused on elderly patients with multisystem organ dysfunction, and the findings may not be applicable to other patient population. Finally, the sample size was relatively small. These limitations should be considered when interpreting the results of this study.

CONCLUSION

According to this study, there was a reasonable degree of discrimination and calibration in both the MPM0-III and SAPS 3 severity of illness scoring systems, and they both performed well and could be used to predict death in elderly critically ill patients. But before implementing severity of illness scoring systems in clinical practice, it is crucial to calibrate and validate them, as well as assess their accuracy and dependability across various groups.

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