Review Article

Scoring systems in the intensive care unit: A compendium

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Abstract

Severity scales are important adjuncts of treatment in the intensive care unit (ICU) in order to predict patient outcome, comparing quality-of-care and stratification for clinical trials. Even though disease severity scores are not the key elements of treatment, they are however, an essential part of improvement in clinical decisions and in identifying patients with unexpected outcomes. Prediction models do face many challenges, but, proper application of these models helps in decision making at the right time and in decreasing hospital cost. In fact, they have become a necessary tool to describe ICU populations and to explain differences in mortality. However, it is also important to note that the choice of the severity score scale, index, or model should accurately match the event, setting or application; as mis-application, of such systems can lead to wastage of time, increased cost, unwarranted extrapolations and poor science. This article provides a brief overview of ICU severity scales (along with their predicted death/survival rate calculations) developed over the last 3 decades including several of them which has been revised accordingly.

Keywords: Acute physiology, and chronic health evaluation, beta-coefficients in scoring systems, intensive care unit scoring systems, probability of death calculation

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Introduction

Assessment of medical treatment outcome was started in 1863, when Florence Nightingale first addressed this issue.[1] Initially, outcome prediction in critical illness was based on the subjective judgment of the clinicians. The rapid development of intensive care units (ICUs) created the need for quantitative and clinically relevant surrogate outcome measures in order to evaluate the effectiveness of treatment practices. Hence, scoring systems have been developed and applied for the same. The outcome of intensive care patients depends on several factors present on the 1st day in the ICU and subsequently on the patient's course in ICU. For such populations, many scoring systems have been developed but few are used. Several of these systems are known simply by their acronym.[2] A scoring system usually comprises of two parts – a score (a number assigned to disease severity) and a probability model (equation giving the probability of hospital death of the patients). A model refines the ability of scores or scales to be used in comparing various groups of patients for the purpose of treatment, triage or comparative analysis[3] and thus helps in decision making. They also allow an increased understanding of the effectiveness of treatment and optimizing the use of hospital resources and hence aid in the development of treatment standards. An accurate scoring model should have a high predictive power starting from day one, should not be limited to certain cut-off-points and should be calculated according to the well-known and established formula used for such a purpose with specific β-coefficients.[3,4] The transformation of the (severity) score into a probability of death in the hospital uses a logistic regression equation. The ideal model should be well-validated, calibrated and discriminated. "Validity" is the term usually used to assess the performance of the prediction model by testing in the dataset that was used for model development. "Calibration" evaluates the accuracy of the degree of correspondence concordance

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between the estimated probabilities of mortality produced by a model and the actual mortality experienced by patients population and can be statistically evaluated using formal goodness-of-fit tests.[5] "Discrimination" refers to the ability of the model to distinguish patients who die from patients who live, based on the estimated probabilities of mortality. Measures of discrimination are sensitivity, specificity, false positive rate, false negative rate, positive predictive power, misclassification rate, area under the receiver operating characteristic curve and concordance.[3] This article provides the reader with an interesting compendium of ICU severity scales along with their predicted death and survival rate calculations, which can be adopted in order to improve decision making, treatment, research and in comparative analyses in quality assessment.

Types of ICU Scoring Systems

In most of the scoring systems, scores are calculated from data collected on the first ICU day – acute physiology and chronic health evaluation (APACHE), simplified acute physiology score (SAPS) and mortality prediction model (MPM). Others are repetitive and collect data every day throughout the ICU stay or for the first 3 days - organ dysfunction and infection system (ODIN), sequential organ failure assessment (SOFA), multiple organs dysfunction score (MODS), logistic organ dysfunction (LOD) model and three-day recalibrating ICU outcomes (TRIOS). Scores can be subjective or objective.[5] Subjective scores are established by a panel of experts who choose the variables and assign a weight to each variable based on their personal opinion. E.g., APACHE II, ODIN and SOFA. Objective score variables are collected using the logistic regression modeling techniques and clinical judgment to determine ranges and to assign weights. E.g., APACHE III, SAPS II, MPM II, MODS, LOD score (LODS) and TRIOS. The commonly used ICU scoring systems (for the adult population) discussed in this article are:

- APACHE II
- SAPS II
- MODS
- SOFA
- LODS
- MPM II on admission, 24 h, 48 h, 72 h
- ODIN
- TRIOS
- Glasgow coma score (GCS)

Many studies have shown the effectiveness of scoring systems in predicting hospital mortality and most of the available scores are comparable in terms of outcome prediction.[6,7] Prediction models should however, periodically be updated to reflect the changes in medical practice and case-mix over time.[8] A prospective study by Meyer *et al*.[9] showed that among patients who were predicted by clinical judgment and APACHE II score to die, more than 40% of actually survived. They concluded that no method is reliable for predicting the mortality of surgical ICU patients. This raises the question of what are the desirable characteristics of risk-adjusted mortality predictors and how to avoid the confusion that exists between interpreting an estimated probability of mortality and predicting whether a given patient will live or die.

APACHE II

Developed in 1985 using a database of North American ICU patients, APACHE II [Table 1a and b][1] is the severity of disease classification system. It uses a point score based upon values of 12 routine physiologic measurements (taken during the first 24 h after admission), age and previous health status to provide a general measure of severity of disease. An integer score from 0 to 71 is then computed based on these measurements; higher scores imply a more severe disease and a higher risk of death. APACHE II scores can prognostically stratify acutely ill patients and assist investigators comparing the success of new or differing forms of therapy. If a variable has not been measured, it is assigned zero points. Hospital mortality is predicted using the APACHE II score, the principal diagnostic category with which the patient is admitted to ICU and also depending on whether or not the patient required emergency surgery.[1] The estimated risk of hospital death is calculated using logistic regression equation, utilizing specific beta co-efficients made for its purpose [Tables 1a and b].[1] In a retrospective study of 396 patients by Peter *et al*.[10] the performance of the APACHE II score, the SAPS II, MPM II and the poisoning severity score (PSS) was evaluated; they found that even in the setting of poisoning, the generic scoring systems APACHE-II and SAPS-II outperform the PSS. However, the APACHE II score is neither very sensitive nor specific in terms of mortality prediction. The major limitation of this scoring system is that many patients have several co-morbid conditions and selecting only one principal diagnostic category may be very difficult. In addition, the physiological variables are all dynamic and can be influenced by multiple factors, including ongoing resuscitation and treatment, hence, time bias is present; which is an important consideration when treating patients in the ICU especially with recent increased emphasis on the importance of an early goal directed therapies.[11] All these factors can lead to a risk of overestimation of predicted mortality.

The APACHE III prognostic system was designed to refine APACHE II. It consists of two parts:[12]

- APACHE III score, which can provide initial risk stratification for severely ill hospitalized patients within independently defined patient groups
- APACHE III predictive equation, which uses APACHE III score and reference data on major disease categories and treatment location immediately prior to ICU admission to provide risk estimates for hospital mortality for individual ICU patients.

APACHE III largely uses the same variables as APACHE II, but a different way is used to collect the neurological data-no longer using the GCS. It adds particularly two important variables: The patient's origin and the lead-time bias. The acute diagnosis is taken into account; one diagnosis must be preferred.[12] The APACHE III scores (evaluated as the most deranged values from the first 24 h in the ICU) vary between 0 and 299 points, including 252 points for the 18 physiological variables, 24 points for age and 23 points for the chronic health status; all variables are chosen to increase the explanatory power of the model.[13]

APACHE IV was gradually developed,[14] using day 1 data for 1,16,209 ICU admissions and using the same variables as APACHE III. New variables added were: Mechanical ventilation, thrombolysis, impact of sedation on GCS, re-scaled GCS and PaO_2/FiO_2 (arterial oxygen tension and fractional concentration of inspired oxygen) ratio.

SAPS II

First described in 1993 by Le Gall *et al.*,[15] SAPS II [Table 2][15] is used to score the ICU patients' severity. The model includes 17 variables: 12 physiologic variables, age, type of admission and three disease-related variables. As with other scoring systems, the SAPS II score registers the worst value of selected variables, within the first 24 h after admission. The SAPS II score can vary between 0 and 163 points (0-116 points for physiological variables, 0-17 points for age and 0-30 points for previous diagnosis). Probability of death is then calculated using logistic regression [Table 2].[15] However, the discrimination and particularly the calibration of the SAPS II model

Table 1a: Acute physiologic and chronic health evaluation (APACHE II)[1]

A: Acute physiological score (12 variables)

Physiologic variable	High abnormal range				Normal range	Low abnormal range			
	+4	+3	+2	+1	0	+1	+2	+3	+4
Temperature rectal (°C)	≥41	39-40.9	-	38.5-38.9	36-38.4	34-35.9	32-33.9	30-31.9	≤29.0
Mean arterial pressure (mm Hg)	≥160	130-159	110-129		70-109		50-69		≤49
Heart rate-ventricular response	≥180	140-179	110-139		70-109		55-69	40-54	≤39
Respiratory rate per minute-non-ventilated or ventilated	≥50	35-490		25-34	12-24	10-11	6-9		≤5
Oxygen: A-a DO_2 or PaO_2 (Torr)									
FiO_2≥0.5 record A-a DO_2	≥500	350-499	200-349		≤200	PO_2 61-70		PO_2 55-60	PO_2<55
FiO_2<0.5 record only PaO_2					PO_2>70				
Arterial pH	≥7.7	7.6-7.69		7.5-7.59	7.33-7.49		7.25-7.32	7.15-7.24	<7.15
Serum HCO_3 (mmol/L)-only if no ABGs	≥52	41-51.9		32-40.9	23-31.9		18-21.9	15-17.9	<15
Serum sodium (mmoL/L)	≥180	160-179	155-159	150-154	130-149		120-129	111-119	≤110
Serum potassium (mmoL/L)	≥7	6-6.9		5.5-5.9	3.5-5.4	3-3.4	2.5-2.9		≤2.5
Serum creatinine (μmoL/L)	≥350	200-340	150-190		60-140		<60		
Hematocrit (%)	≥60		50-50.9	46-49.9	30-45.9		20-29.9		≤20
White blood cell count (×1,000/mm³)	≥40		20-39.9	15-19.9	3-14.9		1-2.9		<1
Glasgow coma score=15 minus actual GCS									

B: Age points		C: Chronic health points			Apache II score
Age (years)	Points	History	Points for elective surgery	Points for emergency surgery	Sum of A+B+C
≤44	0	Liver: Biopsy-proven cirrhosis and documented portal hypertension or prior episodes of hepatic failure	2	5	A: APS
45-54	2	Cardiovascular: NYHA Class IV	2	5	B: Age points
55-64	3	Respiratory: e.g., severe COPD, hypercapnia, home O_2, pulmonary hypertension	2	5	score
65-74	5	Immunocompromised	2	5	C: Chronic health
≥75	6	Renal: Chronic dialysis	2	5	point score
Total score					

APACHE: Acute physiology and chronic health evaluation; A-a DO_2: Alveolar-arterial oxygen tension difference; PaO_2 (Torr) arterial oxygen tension; FiO_2 (%): Fractional concentration of inspired oxygen; HCO_3: Bicarbonate; ABG: Arterial blood gas; NYHA: New York heart association; COPD: Chronic obstructive pulmonary disease. To compute predicted death rates for groups of acutely ill patients, the individual risk of hospital death is calculated with the following equation; the individual risks are then summed up and the value is divided by the total number of patients. *R*/1-*R*=–3.517+(APACHE II score×0.146)+(0.603, only if post-emergency surgery)+(diagnostic category weight as shown below), where *R* is the estimated risk of hospital death

do not fit when applied to a new population. Therefore, to calculate the standardized mortality ratio or the ICU performance measure, a proposal was recently made by Le Gall *et al*.,[16] where six admission variables were added to SAPS II: Age, sex, length of the ICU hospital stay, patient location before ICU, clinical category and whether drug overdose was present or not. Probability of death (*P*) for this expanded model is again calculated using logistic regression, where:

A world-wide database of 19,577 patients was then used to develop SAPS III in 2005,[17,18] comprising of three parts: chronic variables, acute variables including the sepsis and its characteristics and physiology. Data are acquired within 1st h of admission. The calculated probability of ICU and hospital death emerges by adding diagnoses to the model. Recently, Liu *et al*., developed an electronic SAPS 3, which was tested among 67,889 first-time ICU admissions at 21 hospitals between 2007 and 2011 to predict hospital mortality. This customized eSAPS 3 version was also developed in a 40% derivation cohort and tested in a 60% validation cohort; they concluded that this eSAPS 3 shows good potential for providing automated risk adjustment in the ICU.[19]

MODS

In an article in 1995 Marshall *et al*.[20] proposed an objective scale to measure the severity of multiple organ dysfunction as an outcome in critical illness and tested these criteria in a population of 692 patients. They developed the MODS [Table 3],[20] which comprises a score based on six organ failures. Scores were given from 0 to 4 (maximum of 24). Hospital mortality is then estimated after adding the total scores [Table 3].[20] This score correlated in a graded fashion with the ICU mortality rate, both when applied on the first day of ICU admission as a prognostic indicator and when calculated over the ICU stay as an outcome measure. The score showed excellent discrimination and that mortality depends not only on the admission score but also on the course of ICU stay and therefore, may prove useful

Table 1b: Acute physiologic and chronic health evaluation II-diagnostic category weight[1]

Non-operative	Y	Post-operative patients	Y
Respiratory failure or insufficiency from		Multiple trauma	−1.684
Asthma/allergy	−2.108	Admission due to chronic cardiovascular disease	−1.376
COPD	−0.367	Peripheral vascular surgery	−1.315
Pulmonary edema (non-cardiogenic)	−0.251	Heart valve surgery	−1.261
Post-respiratory arrest	−0.168	Craniotomy for neoplasm	−1.245
Aspiration/poisoning/toxic	−0.142	Renal surgery for neoplasm	−1.204
Pulmonary embolus	−0.128	Renal transplant	−1.042
Infection	0	Head trauma	−0.955
Neoplasm	0.891	Thoracic surgery for neoplasm	−0.802
Cardiovascular failure or insufficiency from		Craniotomy for ICH/SDH/SAH	−0.788
Hypertension	−1.798	Laminectomy and other spinal cord surgery	−0.699
Rythm disturbance	−1.368	Hemorrhagic shock	−0.682
Congestive heart failure	−0.424	GI bleeding	−0.617
Hemorrhagic shock/hypovolemia	0.493	GI surgery for neoplasm	−0.248
Coronary artery disease	−0.191	Respiratory insufficiency	−0.140
Sepsis	0.113	GI perforation/obstruction	0.060
Post cardiac arrest	0.393	If not in one of the above, which major vital organ system led to ICU admission post-surgery	
Cardiogenic shock	−0.259	Neurologic	−1.150
Dissecting thoracic/abdomina aneurysm	0.731	Cardiovascular	−0.797
Trauma		Respiratory	−0.610
Multiple trauma	−1.228	Gastro-intestinal	−0.613
Head injury	−0.517	Metabolic/renal	−0.19
Neurologic			
Seizure disorder	−0.584		
ICH/SDH/SAH	0.723		
Other			
Drug overdose	−3.353		
Diabetic ketoacidosis	−1.507		
Gastro intestinal bleeding	0.334		
If not in one of the groups above, which major organ system was the principal reason for admission			
Metabolic/renal	−0.885		
Respiratory	−0.890		
Neurologic	−0.759		
Cardiovascular	0.470		
GI	0.501		

ICH: Intra cranial hypertension; SDH: Sub dural hematoma; SAH: Sub arachnoid hemorrhage; COPD: Chronic obstructive pulmonary disease; GI: Gastrointestinal

Table 2: Simplified acute physiology score II[15]

Variables	Score																			
	26	13	12	11	9	7	6	5	4	3	2	0	1	2	3	4	6	7	9	10
HR (beats/min)				<40							40-69	70-119				120-159		≥160		
SBP (mmHg)		<70						70-99				100-199		≥200						
Temperature (°C)												<39			≥39					
PaO_2/FiO_2 only if VENT or CPAP				<100	100-199	≥200														
Urine output (L/day)				<0.5					0.5-0.999			≥1								
Urea (g/L)												<0.6					0.6-1.7			>1.8
TLC			<1									1-19.9		≥20						
Potassium										<3		3-4.9		≥5						
Sodium								<125				125-144	≥145							
Bicarbonate							<15			15-19		>20								
Bilirubin (mg/dl)												<40				40-59.9			≥60	
GCS	<6	6-8				9-10		11-13				14-15								

Age	Score	Chronic disease	Score	Type of admission	Score
<40	0	Metastatic cancer	9	Scheduled surgical	0
40-59	7	Hematological malignancy	10	Medical	6
60-69	12	AIDS	17	Emergency surgical	8
70-74	15				
75-79	16				
>80	18				
SAPS II score	29	40	52	64	77
Mortality risk %	10	25	50	75	90

GCS: Glasgow coma score; HR: Heart rate; SBP: Systolic blood pressure; PaO_2 (mm Hg) arterial oxygen tension; FiO_2: Fractional concentration of inspired oxygen; VENT: Ventilator; CPAP: Continuous positive airway pressure; TLC: Total leukocyte count; AIDS: Acquired immunodeficiency syndrome. Probability of death, *P* may be calculated using the following equation: $P=(e^{Logit})/(1+e^{Logit})$; Logit=−7.7631+0.0737 (score)+0.9971 (log [score+1])

as an alternative end point for clinical trials involving critically ill patients.

SOFA

The SOFA system [Table 4] was created in a consensus meeting of the European Society of Intensive Care Medicine in 1994 and further revised in 1996.[21] In 1998, Vincent *et al*.[22] evaluated the SOFA subjective score on 1449 patients. This score was developed to quantify the severity of patients illness, based on the degree of organ dysfunction data on six organ failures and are scored on a scale of 0-4. One failure plus a respiratory failure indicate the lowest mortality; all the other combinations yield mortality between 65% and 74%. Subsequent analyses have considered the maximal score plus the maximal change and have shown that the latter has a lower prognostic value than the former; the time course of the patient's condition during the entire ICU stay is also taken into account.[23] Although there is no direct conversion of SOFA score to mortality, a rough estimate of mortality risk may be made based on two prospective papers that have been published [Table 4].[21,22,24]

Sequential assessment of organ dysfunction during the first few days of ICU admission is a good indicator of prognosis. A prospective study by Bale *et al.* showed that both the mean and highest SOFA scores are particularly useful predictors of outcome, independent of the initial score and a high SOFA score at 48 h of presentation

Table 3: Multiple organ dysfunction score[20]

Multiple organ dysfunction score					
Organ system and their variables	Score				
	0	1	2	3	4
Hematologic: Platelet count ($\times 10^3/mm^3$ or $10^9/L$)	>120	81-120	51-80	21-50	≤20
Hepatic: Serum bilirubin (μmol/L)	≤20	21-60	61-120	121-240	>240
Renal: Serum creatinine (μmol/L)	≤100	101-200	201-350	351-500	>500
Cardiovascular: PAR*	≤10	10.1-15	15.1-20	21-30	>30
Glasgow coma score	15	13-14	10-12	7-9	≤6
Respiratory: PO_2/FiO_2	>300	226-300	151-225	76-150	≤75
Score	0	1-4	5-8 9-12	13-16 17-20	21-24
ICU mortality %	0	1-2	3-5 25	50 75	100

ICU: Intensive care unit; CVP: Central venous pressure (mmHg); GCS: Glasgow coma score; HR: Heart rate (beats/min); MAP: Mean arterial pressure (mmHg); PAR: Pressure adjusted heat rate (which is calculated as the product of the HR and the ratio of CVP to MAP); PaO_2 (Torr) arterial oxygen tension; FiO_2: Fractional concentration of inspired oxygen. If the result for a specific test is not available, then a score of 0 is used for that test. The serum creatinine concentration is measured without the use of dialysis and the PO_2/FiO_2 ratio (PO_2 in mmHg and FiO_2 in %) is calculated without the use of mechanical ventilation or positive end-expiratory pressure

predicts an increased mortality rate.[25] In their study, Ferreira *et al*.[24] determined that, regardless of the initial score, an increase in SOFA score during the first 48 h in the ICU predicts a mortality rate of at least 50%. Vosylius *et al*.[26] showed that cumulative SOFA scores were better in discriminating outcome compared to a single organ dysfunction scores. A study published in 2007, Grissom *et al*.[27] proposed and published a simplified version of the SOFA score known as the

Modified SOFA (MSOFA) score. The MSOFA score eliminates the necessity of laboratory examinations such as the platelet count and substitute measurements of PaO_2/FiO_2 and serum bilirubin level with the SPO_2/FiO_2 ratio (obtained by dividing pulse oxymeter saturation with a fraction of inspired oxygen) and clinical examination for jaundice. Although simpler, this score has to have more validation.

LODS

Le Gall *et al*.[28] initially proposed the LODS [Table 5] [7,28,29] in 1996, where 12 variables were tested and six organ failures defined. The model has been tested over time. The difference between the LODS on day 3 and day 1 is highly predictive of the hospital outcome. The LODS was designed to combine measurement of the severity of multiple organ dysfunctions into a single score. The probability of death is then calculated using an equation designed for its purpose [Table 5].[7,28,29]

In a prospective multicenter study on 1685 ICU patients, Timsit *et al*.[29] concluded that daily LOD and SOFA scores showed good accuracy and internal consistency and they could be used to adjust the severity for events occurring in the ICU. Another prospective study by Kim and Yoon in 521 consecutive patients admitted to the neurological ICU, showed that both the LODS and the APACHE II score had excellent discrimination but LODS had superior calibration; they therefore, concluded that the LODS was more stable than the APACHE II scoring system in the neurological ICU setting.[30] However, Maccariello *et al*.[7] evaluated the performance of LODS in patients receiving renal replacement therapy and found poor correlation between LODS score and predicted mortality rate. They attributed this poor correlation to the fact that it was studied in an older and rather severely ill population due to high frequencies of comorbidity, sepsis, functional capacity impairment and need for mechanical ventilation and vasoactive amines.

Table 4: Sequential organ failure assessment score[21,22,24]

Organ system	Score					
	Variable	0	1	2	3	4
Pulmonary	Lowest PaO_2 (Torr)/FiO_2 (%)	>400	≤400	≤300	≤200+respiratory support	≤100+respiratory support
Coagulation	Lowest platelet ($10^3/mm^3$)	>150	≤150	≤100	≤50	≤20
Hepatic	Highest bilirubin (μmol/L)	<20	20-32	33-101	102-204	>204
Circulatory	Blood pressure status	Mean arterial pressure (mmHg) >70	Mean arterial pressure (mmHg) <70	Dopamine* dose≤5 or dobutamine any dose	Dopamine dose>5 or epinephrine≤0.1 or norepinephrine≤0.1	Dopamine dose>15 or epinephrine>0.1 or norepinephrine>0.1
Neurologic	GCS	15	13–14	10-12	6–9	<6
Renal	Highest creatinine level (μmol/L)	<110	110-170	171-299	300-440	>440
	Total urine output (mL/24 h)				<500	<200
Score	0-6	7-9	10-12	13-14	15	15-24
Score %	<10	15-20	15-20	50-60	>80	>90

PaO_2: (Torr) arterial oxygen tension; FiO_2: Fractional concentration of inspired oxygen; GCS: Glasgow coma score

Table 5: Logistic organ dysfunction score[7,28,29]

Measurements of organic systems	5	3	1	0	1	3	5
Neurological (GCS)	3-5	6-8	9-13	14-15			
Cardiovascular							
HR (beats/min)	<30	40-69	70-89	30-139	≥140		
SBP (mmHg)	<40			0-239	240-269	≥270	
Renal							
Ureic nitrogen (mmol/L)	-	-	-	<6	6-9.98	9.99-19.98	≥19.99
Serum creatinine (μmol/L)	-	-	-	<106.08	106.08-140.55	≥141.44	-
Urine output (L/24 h)	<0.5	0.5-0.74	-	0.75-0.99	-	≥10	-
Respiratory							
PaO_2 (Torr)/FiO_2 (%) in MV or CPAP	-	<150	≥150	With no ventilation, CPAP or IPAP	-	-	-
Hematologic							
TLC (mm^3)×10^3	-	<1.0	1.0-2.4	2.5-49.9	≥50	-	-
Platelets (mm^3)×10^3	-	-	<50	≥50	-	-	-
Hepatic							
Serum bilirubin (μmol/L)				<34.2	≥34.2		
PT (seconds and %)			<25	<3 s, >25	≥3 s		

LOD: Logistic organ dysfunction; GCS: Glasgow coma score; HR: Heart rate; SBP: Systolic blood pressure; PaO_2: (Torr) arterial oxygen tension; FiO_2: Fractional concentration of inspired oxygen; MV: Mechanical ventilation, CPAP: Continued positive airways pressure; IPAP: Intermittent positive airways pressure; TLC: Total leucocyte count; PT: Prothrombin time. The probability of death is then calculated using the formula: Probability of death=$e^{logit}/(1+e^{logit})$. Logit=−3.4043+0.4173 (LOD score)

MPM II

First described by Lemeshow *et al*.[31] MPM II [Table 6] is a model giving the probability of hospital death directly. Four models have been proposed: MPM II at admission and at 24, 48 and 72 h. The initial version of this model was designed to predict mortality at hospital discharge based on data from admission and after the first 24 h in the ICU.[32] Additional models were later developed and included data from 48 to 72 h after admission to the ICU. This model uses chronic health status, acute diagnosis, a few physiological variables and some other variables including mechanical ventilation. The MPM II at 48 and 72 h use the same variables as MPM II at 24 h and are based on the most deranged values of the preceding 24 h with different weights to compute the probabilities of death using logistic regression [Table 6].[33,34]

Table 6: Mortality probability models[33,34]

Variables	Values (1 if yes, 0 otherwise) except for age	Beta coefficients
MPM II-admission		
Medical or unscheduled surgery admission	1/0	1.19098
Metastatic neoplasm	1/0	1.19979
Cirrhosis	1/0	1.13681
Chronic renal insufficiency	1/0	0.91906
CPR prior to admission	1/0	0.56995
Coma (GCS 3-5)	1/0	1.48592
Heart rate≥150	1/0	0.45603
SBP≤90 mmHg	1/0	1.06127
Acute renal insufficiency	1/0	1.48210
Cardiac dysrhythmia	1/0	0.28095
Cerebrovascular incident	1/0	0.21338
GI bleeding	1/0	0.39653
Intracranial mass effect	1/0	0.86533
Mechanical ventilation	1/0	0.79105
Age		
MPM II-24, 48, 72 h		
Medical or unscheduled surgery admission	1/0	0.83404
Metastatic neoplasm	1/0	1.16109
Cirrhosis	1/0	1.08745
Creatinine>177 μmol/L	1/0	0.72283
Urine output<50 mL/8 h	1/0	0.82286
Coma (GCS 3-5)	1/0	1.68790
Confirmed infection	1/0	0.49742
Intracranial mass effect	1/0	0.91314
Mechanical ventilation	1/0	0.80845
Vasoactive drugs≥1 h	1/0	0.71628
PaO_2<60 Torr (<7.98 kPa)	1/0	0.46677
Prothrombin time>standard+3 s	1/0	0.55352
Age		

GI: Gastrointestinal; ICU: Intensive care unit; CT: Compute tomography; SBP: Systolic blood pressure; CPR; Cardio pulmonary resuscitation; GCS: Glasgow coma score. Patients excluded are: Age<18 years, burn patients and cardiac patients. Intracranial mass effect: Intracranial mass (abscess, tumor, hemorrhage) as identified by CT scan associated with midline shift or obliteration or distortion of cerebral ventricles or gross hemorrhage in cerebral ventricles or subarachnoid space or visible mass>4 cm or any mass that enhances with contrast media. If the mass effect is known within 1 h of ICU admission, it can be indicated as yes. CT scanning is not mandatory; it is indicated only for patients with major neurological insult. Predicted death rate is calculated as: Predicted death rate=(e^{Logit})/(1+e^{Logit}t). Logit=Sum (values×beta)+age×0.03057-5.46836; MPM: Mortality probability models; GCS: Glasgow Coma Score; PaO_2: (Torr) arterial oxygen tension. Predicted death rate is calculated as: Predicted death rate=(e^{Logit})/(1+e^{Logit}). Logit=Sum (values×beta)+age×0.03268-(5.64592 if MPM 24)-(5.392 if MPM 48)-(5.238 if MPM 72)

ODIN System

Fagon *et al*.[35] proposed the ODIN system [Table 7][7,35] in 1993. This includes data recorded within the first 24 h of ICU admission if there is any presence or absence of dysfunction in six organs plus one infection and it differentiates the prognosis according to the type of failures; the highest mortality rates was found to be associated with hepatic followed by hematologic and renal dysfunctions and the lowest with respiratory dysfunction and infection. Taking into account both the number and the type of organ dysfunction, a logistic regression model was then used to calculate individual probabilities of death that depended upon the statistical weight assigned to each ODIN (in the following order of descending severity: Cardiovascular, renal, respiratory, neurologic, hematologic, hepatic dysfunctions and infection).

TRIOS

In 2001, Timsit *et al*.[36] proposed a composite score, the TRIOS [Table 8],[36] using daily SAPS II and LODS for predicting hospital hospitality in ICU patients hospitalized for more 72 h. Using logistic regression, the probability of hospital mortality can be computed [Table 8][36] This TRIOS composite score has excellent statistical qualities and may be used for research purposes.[5]

Table 7: Organ dysfunctions and/or infection[7,35]

Organ system dysfunction	Variables	Values (1 if yes, 0 otherwise)
Respiratory	PaO_2<60 Torr (FiO_2=0.21) or need for ventilatory support	
Cardiovascular	SBP<90 mmHg with signs of peripheral hypoperfusion or continuous infusion of vasopressor or inotropic agent to maintain SBP>90 mmHg	
Renal	Serum creatinine>300 μmol/L or urine output<500 mL/24 h or<180 mL/8 h or need for hemodialysis or peritoneal dialysis	
Neurologic	GCS<6 (in absence of sedation at any time in the day) or sudden onset of confusion or psychosis	
Hepatic	Serum bilirubin>100 μmol/L or alkaline phosphatase>3 times normal value	
Hematologic	Hematocrit≤20% or TLC<2000/mm^3 or platelet count<40000/mm^3	
Infection (with clinical evidence)	2 positive blood cultures or presence of gross pus in a closed space or source of the infection determined during hospitalization or at autopsy in case of death within the 24 h	

PaO_2: (Torr) arterial oxygen tension; FiO_2: Fractional concentration of inspired oxygen; SBP: Systolic Blood Pressure; GCS: Glasgow coma score; TLC: Total leucocyte count. Probability of death is calculated using the formula: Probability of death=e^{logit}/(1+e^{logit}). Logit=−3.59+(1.09×respiratory)+(1.19×cardiovascular)+(1.18×renal)+(0.86×hematologic+(0.57×liver)+(0.99×neurologic)+(0.53×infection)

GCS

The GCS [Table 9] is a universal tool for the rapid assessment of an injured[37] patient's consciousness level and as a guide to the severity of brain injury.[38] Several studies have shown that there is a good correlation between GCS and neurological outcome.[39,40] A modified verbal and motor version has been developed to aid in the evaluation of the consciousness level of infants and children.[41,42] [Table 9].

Table 8: TRIOS (3 days recalibrated ICU outcome score)[36]

Variables	Value: 1 if yes, 0 otherwise (except for LODS and SAPS II admission)
Transfer from ward	
Chronic illness	
SAPS II day 2-SAPS II day 3 alteration	
LODS day 2-LODS day 3 alteration	
LODS on admission	
SAPS II on admission	

TRIOS: Three-day recalibrating ICU outcomes; ICU: Intensive care unit; LODS: Logistic organ dysfunction score; SAPS: Simplified acute physiology score. To compute the probability of hospital mortality, *P*: P (e^{Logit})/(1+e^{Logit}) where e=2.7182818 (the base of the natural logarithm). Logit=(−4.44)+0.5543 (transfer from ward) +0.1536 (LOD on admission)+0.0388 (SAPS II on admission)+0.8507 (chronic illness)+0.4161 (SAPS2-SAPS3 alteration)+0.6940 (LOD2-LOD3 alteration)

Table 9: Glasgow coma score[37]

Score	Best eye response (E)
1	No eye opening
2	Eye opening to pain
3	Eye opening to verbal command
4	Eyes open spontaneously
Score	**Best verbal response (V)**
1	No verbal response
2	Incomprehensible sounds
3	Inappropriate words
4	Confused
5	Oriented
Score	**Best motor response (M)**
1	No motor response
2	Extension to pain
3	Flexion to pain
4	Withdrawal from pain
5	Localizing pain
6	Obeys commands

A coma score of 13 or higher correlates with a mild brain injury, 9-12 is a moderate injury and 8 or less a severe brain injury

The pediatric Glasgow coma scale[41,42]

Score	Eye opening	Verbal response	Motor response
6	-	-	Normal, spontaneous, obeys commands
5	-	Age-appropriate words, social smile, fixes and follows	Localizes pain
4	Spontaneous	Cries, but consolable	Withdraws from pain
3	To voice	Persistently irritable	Flexion posture to pain
2	To pain	Restless agitated	Extension posture to pain
1	None	None	None

Conclusion

Prediction models do face many challenges. Some of the desirable characteristics of risk-adjusted mortality predictors are that no lead-time bias should be present and they should not be affected by whether a patient is hospitalized or not. Albeit imperfect, the existing models have increased application in decision making at the right time and in decreasing hospital cost. It is also imperative that the choice of the severity score scale, index, or model accurately match the event, setting or application, as mis-application of such systems can result in avoidable wastage of time, increase in cost incorrect extrapolations and may contribute to mismanagement and death.

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