

# Illness severity and organ dysfunction scoring in Pediatric Intensive Care Unit

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## Abstract

The illness severity scoring systems provide objective measures for inter- and intra-unit comparisons with time and also provide useful information for comparing the severity of illness of patients, at the time of enrollment into clinical trials. These scores are an essential part of the improvement in clinical decisions and in stratifying patients with poor outcomes. Appropriate application of these models helps in decision-making at the right time and in decreasing mortality. However, it is also important to note that the choice of illness scores should accurately match the setting in which they are designed. In Indian setting, there is no Pediatric Intensive Care Unit illness severity score is designed until now as per our patient profile and resources. The purpose of this review article is to provide an idea regarding the evolution of illness severity scores in developed countries till date along with their utility. This review emphasizes the need for the development of pediatric illness severity score as per the local resources.

**Keywords:** Pediatric index of mortality, pediatric logistic organ dysfunction, pediatric risk of mortality

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## Introduction

Critically ill children are characterized by large variations in the normal body homeostasis. These variations can be estimated by the drift of the physiological variables from the normal range. Scores can be constructed from deviations of these drifted variables. Broadly, these scores can be divided into two categories. The first category belongs to the prognostic scores which predict the risk of death at the time of entry into Intensive Care Unit (ICU). The other category is of the descriptive or outcome scores which describe the course of illness after the admission into the ICU. The scoring systems provide objective measures for inter- and intra-unit comparisons with time and also provide useful information for comparing the severity of illness of patients, at the time of enrollment into clinical trials.<sup>[1]</sup> In this review,

two most frequently used predictive scores in Pediatric ICU (PICU) - pediatric risk of mortality (PRISM) and the pediatric index of mortality (PIM) scores and one descriptive score to assess the multiorgan dysfunction, pediatric logistic organ dysfunction score (PELODS) are discussed [Table 1]. Text material was collected by a systematic search in PubMed, Google (1984–2013) for original articles. Few paid articles were obtained from National Medical Library New Delhi, India.

## Prognostic Scores

### *Pediatric risk of mortality score*

PRISM scores are generally used in sick neonates, infants, children, or adolescents. Three versions of PRISM

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have been published till date. The first version was named as Physiologic Stability Index (PSI) which was a subjective score developed by a panel of intensivists, containing 34 physiological variables from seven physiologic systems of the body.<sup>[2]</sup> PSI was developed from the Therapeutic Intervention Scoring System which reflects the severity of illness by assessing therapeutic needs. Each variable was assigned a score of 1 (abnormality worth concern but not to change therapy), 3 (need to change therapy), and 5 (life-threatening). As the PSI score contained a large number of physiological variables and it was a subjective score, Pollack published PRISM score (an improved version of the PSI) in 1988.<sup>[1]</sup> Data were collected from nine PICUs during 1984 and 1985 in North America. The number of physiologic variables had been decreased from 34 to 14, and the number of ranges had been decreased from 75 to 23 compared to PSI. It has been shown that PRISM II score was easier to calculate and is a better reflection of the severity of illness than PSI.<sup>[3]</sup> One of the major limitation of the PRISM score was its underestimation of deaths after cardiac surgery.

PRISM III, a third-generation was developed in 1996 based on a sample size of 11,165 patients from 32 pediatric ICUs all over North America.<sup>[4]</sup> Physiologic variables reflective of mortality risk were re-evaluated to update. Age groups were defined as follows: Neonates (0 to <1 month), infants (1-12 months), child (>12-144 months), and adolescent (>144 months). Subscores used were: (1) Cardiovascular and neurologic vital signs: Five parameters (2) acid-base and blood gas: Five parameters (3) biochemistry tests: Four parameters (4) hematology tests: Three parameters (prothrombin time and activated partial thromboplastin time counted as one). PRISM III contains 17 variables and the predictive power of the physiologic variables were objectively assessed and their ranges, eliminating some ranges that did not contribute significantly to mortality risk (e.g., high systolic blood pressure [SBP]), and revising the ranges of the retained physiologic variables. Variables such as temperature, pH, arterial oxygen pressure (PaO<sub>2</sub>), creatinine, blood urea nitrogen, white blood cell count, and platelet count have been added [Table 2]. Although

**Table 1: Commonly used scoring systems in Pediatric Intensive Care Unit**

Prognostic scores	Descriptive scores
PRISM (PRISM/PRISM II, PRISM III)	PELODS (PELODS-1, PELODS-2)
PIM scores (PIM-1, PIM-2, PIM-3)	PEMODS PCPC POPC

PRISM: Pediatric risk of mortality; PIM: Pediatric index of mortality; PELODS: Pediatric logistic organ dysfunction score; PEMODS: Pediatric multiple organ dysfunction score; PCPC: Pediatric cerebral performance category; POPC: Pediatric overall performance category

**Table 2: Pediatric risk of mortality III score**

Cardiovascular and neurologic vital signs	Findings	Points	
Systolic blood pressure (mmHg)	Neonate and >55	0	
	Neonate and 40-55	3	
	Neonate and <40	7	
	Infant and >65	0	
	Infant and 45-65	3	
	Infant and <45	7	
	Child and >75	0	
	Child and 55-75	3	
	Child and <55	7	
	Adolescent and >85	0	
	Adolescent and 65-85	3	
	Adolescent and <65	7	
	Heart rate (beats/min)	Neonate and <215	0
		Neonate and 215-225	3
		Neonate and >225	4
Infant and <215		0	
Infant and 215-225		3	
Infant and >225		4	
Child and <185		0	
Child and 185-205		3	
Child and >205 bpm		4	
Adolescent and <145 bpm		0	
Temperature (°C)	Adolescent and 145-155 bpm	3	
	Adolescent and >155 bpm	4	
	<33	3	
Mental status	33-40	0	
	>40	3	
	Glasgow coma score ≥8	0	
Pupillary response	Glasgow coma score <8	5	
	Both reactive	0	
	One reactive and (1 fixed and >3 mm)	7	
	Both fixed and both >3 mm	11	

The heart rate should not be monitored during crying or iatrogenic agitation; Pupillary size should not be assessed after iatrogenic dilatation; Body temperature may be rectal, oral, axillary or blood; Mental status should not be scored within 2 h of sedation, paralysis or anesthesia. If sedation, paralysis or anesthesia is continuous, score based status prior to sedation, paralysis or anesthesia

Acid-base and blood gases	Findings	Points
Acidosis (mEq/L)	pH >7.28 and total CO <sub>2</sub> ≥17	0
	pH 7.0-7.28 or total CO <sub>2</sub> 5-16.9	2
	pH <7.0 or total CO <sub>2</sub> <5	6
pH	<7.48	0
	7.48-7.55	2
	>7.55	3
PCO <sub>2</sub> (mmHg)	<50	0
	50-75	1
	>75	3
Total CO <sub>2</sub> (mEq/L)	≤34	0
	>34	4
PaO <sub>2</sub> (mmHg)	≥50	0
	42.0-49.9	3
	<42	6

PaO<sub>2</sub> requires arterial blood; PCO<sub>2</sub> can be measured from arterial, venous or capillary specimens

Chemistry tests	Findings	Points
Glucose (mg/dL)	≤200	0
	>200	2
Potassium (mEq/L)	≤6.9	0
	>6.9	3
Creatinine (mg/dL)	Neonate and ≤0.85	0
	Neonate and >0.85	2
	Infant and ≤0.90	0

Contd...

**Table 2: Contd...**

Chemistry tests	Findings	Points
BUN (mg/dL)	Infant and >0.90 mg/dL	2
	Child and ≤0.90 mg/dL	0
	Child and >0.90 mg/dL	2
	Adolescent and ≤1.30 mg/dL	0
	Adolescent and >1.30 mg/dL	2
	Neonate and ≤11.9	0
	Neonate and >11.9	3
	Not neonate and ≤14.9	0
	Not neonate and >14.9	3

Whole blood measurements for glucose are increased 10% over serum; for potassium 0.4 mEq/L

Hematologic tests	Findings	Points
White blood cell count (/ $\mu$ L)	≥3000	0
	<3000	4
Platelet count (/ $\mu$ L)	>200,000	0
	100,000-200,000	2
	50,000-99,999	4
	<50,000	5
PT and PTT	Neonate and PT ≤22 s and PTT ≤85 s	0
	Neonate and (PT >22 s or PTT >85 s)	3
	Not neonate and PT ≤22 s and PTT ≤57 s	0
	Not neonate and (PT >22 s or PTT >57 s)	3

The upper limit of the normal reference ranges for PT and PTT are not given

#### Other factors to document

Nonoperative cardiovascular disease

Chromosomal anomaly

Cancer

Previous ICU admission during current admission

Pre-ICU CPR during current admission

Postoperative (not including catheterizations) during past 24 h

Acute diabetes with ketoacidosis or other severe complication

Admission from inpatient unit (do not count if in ICU for <2 h or if transferred from surgical recovery room) cardiovascular and neurologic subscore=(points for systolic pressure) + (points for temperature) + (points for mental status) + (points for heart rate) + (points for pupillary reflex)

Acid-base and blood gas subscore=(points for acidosis) + (points for pH) + (points for PaCO<sub>2</sub>) + (points for total CO<sub>2</sub>) + (points for PaO<sub>2</sub>)

Chemistry subscore=(points for glucose) + (points for potassium) + (points for creatinine) + (points for BUN)

Hematology subscore=(points for WBC count) + (points for platelet count) + (points for PT and PTT testing)

Total PRISM III score=(cardiovascular and neurologic subscore) + (acid base and blood gas subscore) + (chemistry subscore) + (hematology subscore)

#### Interpretation

Minimum subscore and total score: 0

Maximum cardiovascular and neurologic subscore: 30

Maximum acid-base and blood gas subscore: 22

Maximum chemistry subscore: 10

The higher the total score, the worse the prognosis

A rising score indicates deterioration

If performed during the first 12 h in the ICU, the score is designated PRISM-12

If performed during the first 24 h in the ICU, it is designated PRISM-24

Predictive equations: Predictive equations for prognosis are available for the 12 h and 24 h scores

PaO<sub>2</sub>: Arterial oxygen pressure; PaCO<sub>2</sub>: Arterial carbon dioxide pressure; CO<sub>2</sub>: Carbon dioxide; BUN: Blood urea nitrogen; PT: Prothrombin time; PTT: Partial thromboplastin time; ICU: Intensive Care Unit; CPR: Cardiopulmonary resuscitation; PRISM: Pediatric risk of mortality

these are important changes, the variables of the greatest importance in outcome prediction are the same in both PRISM and PRISM III such as low SBP, altered mental

status, and abnormal pupillary reflexes were retained. The most abnormal value of the variable is to be noted while entering the data during the first 12 h (PRISM III-12) or during the first 24 h (PRISM III-24) after entry into PICU. PRISM III-24 was very well validated with a large sample size involving a lot of different PICUs. Its discrimination capacity to differentiate between the critically ill children who die and those who survive was  $0.944 \pm 0.021$  (area under receiver operating characteristic [AU-ROC]  $\pm$  standard error of the mean [SEM]) and calibration was excellent ( $P = 0.5504$ ). Pollack also estimated the value of the PRISM III-12 score. The discrimination capacity and calibration of PRISM III-12 were  $0.941 \pm 0.021$  (AU-ROC  $\pm$  SEM) and  $0.4168$ , respectively.<sup>[4]</sup> However, there are several limitations with PRISM. First, many PICUs do not calculate due to its time-consuming process. Second, the units which participated in the validation of this score had over 40% of the deaths in the first 24 h, so there is a danger that the score may diagnose death rather than predicting it. Third, the worst-24-h scores blur the differences between units: A child managed in a well-equipped and high manpower tertiary level center who rapidly recovers will have a score that suggests a mild illness, while the same child who is inadequately managed in a less well equipped and low manpower tertiary level will have a score that suggests severe illness - the less equipped tertiary level ICU's high mortality will be incorrectly attributed to its having sicker patients than the well-equipped unit. Fourth, users have to pay money to get this score resulted in underutilization many countries, outside North America.<sup>[5,6]</sup> Validation of PRISM score outside North America had shown mixed results. A study from Pakistan by Qureshi *et al.*<sup>[7]</sup> had shown good discrimination and calibration of PRISM III (AUC 0.78 [0.67-0.89];  $\chi^2 = 7.49$ ,  $P = 0.49$ ) in their PICU. A study from china by Choi *et al.*<sup>[8]</sup> had shown PRISM III accurately predicted mortality in PICU (AUC 0.79 [0.65-0.98];  $P = 0.395$ ). Another study from India by Taori *et al.*<sup>[9]</sup> showed good discriminatory performance and calibration with PRISM score. A study by Thukral *et al.* from India<sup>[10]</sup> had shown that PRISM underpredicted mortality in their PICU. The likely reasons for underprediction of mortality in their study were attributed to differences in their patient clinical profile, lesser resources, and differences in the quality of care when compared to those ICUs where the score was developed.

In 1997 Pollack *et al.* developed a physiology based measure of physiologic instability that has an expanded scale compared with the PRISM III score and called it as the PRISM III-acute physiology score (PRISM III-APS).<sup>[11]</sup>

PRISM III-APS consists 59 ranges of 21 physiologic variables. Data were collected from 32 PICU's (11,165 admissions, 543 deaths). Patients who had PRISM III-APS score of >80 had mortality >97%. However, this score should not be used routinely for quality assessments or calculating risk of individual patients because it is highly sensitive to small changes in physiological status.

### Pediatric index of mortality

To overcome problems faced with PRISM III, PIM model was designed. The first version (PIM) was published in 1997<sup>[6]</sup> and the score was updated in 2003 (PIM2) and 2013 (PIM3). PIM uses eight physiological variables within 1 h of PICU admission. Data were collected from seven PICUs in Australia and one ICU in the UK. The variables used by PIM that are not used by PRISM are the presence of a specified diagnosis; use of mechanical ventilation and the plasma base excess [Table 3]. The score was well calibrated ( $P = 0.37$ ) and well discriminated (AU-ROC = 0.90).<sup>[6]</sup> The advantages of PIM score are: It is easy to use and available in the public domain at free of cost. A major limitation of PIM is the effect of treatment given prior to admission to the PICU, and it is represented by a problem called lead time bias, i.e., patients with a given severity-of-illness score may have a higher mortality rate if they have

been extensively treated before they are admitted to ICU.<sup>[12]</sup> However, it was found that the time spent in hospital before admission to intensive care was not statistically significant when added to the PIM model.<sup>[6]</sup> In developing countries like India, where preadmission management is not well organized as compared to developed countries, it may not affect the assessment of severity of illness by PIM model.

PIM score was updated in 2003 which was validated in 20,787 critically ill children from 14 ICUs in Australia, New Zealand, and the UK.<sup>[13]</sup> PIM2 has 10 variables with the discrimination value of 0.90 (95% confidence interval, 0.89–0.91) and good calibration ( $P = 0.17$ ). Changes made in PIM2 as compared to PIM are: First, three variables, which provide the main reason for ICU admission, are being added to PIM2: (a) Admission for recovery from surgery or procedure, (b) following cardiac bypass (c) for low-risk diagnosis. Secondly, a variable named "Specific Diagnosis" was replaced by two new variables: "High-Risk Diagnosis" and "Low-Risk Diagnosis." Third, in "High-Risk Diagnosis," the criteria for cardiac arrest had been changed, and liver failure was included along with the removal of Intelligent Quotient below 35 [Table 4].

**Table 3: Pediatric index of mortality score**

Instructions for collecting the information needed to calculate PIM

PIM is calculated from information collected at the time a child is admitted to the ICU. Because PIM describes how ill the child was at the time you started intensive care, the observations to be recorded are those made at or about the time of first face-to-face (not telephone) contact between the patient and a doctor from your ICU (or a doctor from a specialist pediatric transport team). Use the first value of each variable measured within the period from the time of first contact to 1 h after arrival in your ICU. The first contact may be in your ICU, or your emergency department, or a ward in your own hospital, or in another hospital (e.g., on a retrieval). The pupils' reactions to light are used as an index of brain function; do not record an abnormal finding if this is probably caused by drugs, toxins or local injury to the eye. If information is missing (e.g., base excess not measured), record zero (except for systolic blood pressure, which should be recorded as 120); do not leave the space blank

Booked admission to ICU after elective surgery, or elective admission to ICU for a procedure such as insertion of a central line or monitoring or review of home ventilation (no=0, yes=1)

If there is one of these underlying conditions, record the code (number in brackets)

- (0) None
- (1) Cardiac arrest out of hospital
- (2) Severe combined immune deficiency
- (3) Leukemia/lymphoma after first induction
- (4) Cerebral hemorrhage
- (5) Cardiomyopathy or myocarditis
- (6) Hypoplastic left heart syndrome
- (7) HIV infection
- (8) IQ probably <35, worse than Down's
- (9) Neurodegenerative disorder

Response of pupils to bright light (both >3 mm and both fixed=1, other=0, unknown=0)

Base excess in arterial or capillary blood, mmol/L (unknown=0)

PaO<sub>2</sub>, mmHg (unknown=0)

FiO<sub>2</sub> at time of PaO<sub>2</sub> if oxygen via ETT or head box (unknown=0)

Systolic blood pressure, mmHg (unknown=120)

Mechanical ventilation at any time during first hour in ICU (no=0, yes=1)

Outcome of ICU admission (discharged alive from ICU=0, died in ICU=1)

Also consider collecting: ICU admission number, age, diagnosis, days in PICU, intubation (no=0, or yes=1 = an ETT *in situ* at any time during the ICU admission), gestational age (neonates), Apgar score at 5 min (neonates)

PIM: Pediatric Index of Mortality; ICU: Intensive Care Unit; IQ: Intelligent quotient; PaO<sub>2</sub>: Arterial oxygen pressure; FiO<sub>2</sub>: Fraction of inspired oxygen; ETT: Endotracheal tube; PICU: Pediatric Intensive Care Unit

The advantage of PIM2 score is that it avoids problems of early treatment bias as it includes only data at entry into the PICU. Its main weakness is that it has not been tested in many countries around the world. A study from Argentina showed that PIM2 has an adequate discrimination between death and survival but has poor calibration with a reasonable prediction of outcome.<sup>[14]</sup> Ng *et al.* from china, showed that the discrimination of PIM1 and PIM2 were satisfactory, but calibration was not possible due to insufficient deaths.<sup>[15]</sup> Imamura *et al.* from Japan, found that PIM2 has excellent discriminatory power and good calibration, although it over-predicted deaths.<sup>[16]</sup> Sankar *et al.* from India also validated PIM and PIM2 scores in their setup and showed that both PIM and PIM2 scores had good calibration but only acceptable discrimination.<sup>[17]</sup>

### Pediatric index of mortality-3

To ensure the continued applicability of the models, re-calibration using new data should be performed

regularly. Hence, PIM3 was developed using data of 53,112 admissions from various PICUs in Australia, New Zealand, UK, and Ireland<sup>[18]</sup> [Table 5]. The final model well discrimination power (AUC, 0.88, 0.88–0.89); however, in the combined dataset, the model performed better in Australasia than in the UK/Ireland (AUC, 0.92, 0.91–0.93 and 0.87, 0.86–0.88, respectively). Changes made from PIM2 to PIM3 are as follows: (1) Diagnoses influencing the risk of mortality were divided into three categories: Very high-, high-, and low-risk groups. Diagnoses which had odds ratios >5 in the interim multivariable model are classified as very high-risk diagnoses. High-risk diagnoses groups and low-risk diagnoses groups had odds ratios between 1 and 5 and below 1, respectively. In contrast to PIM2, these diagnoses groups were assigned using a categorical variable and patients with multiple weighted diagnoses were assigned to only one group, which have high risk. For example, a patient with hypoplastic left heart syndrome (a high-risk diagnosis) who is admitted

**Table 4: Pediatric index of mortality 2 score**

Systolic blood pressure, mmHg (unknown=120) <sup>a</sup>
Pupillary reactions to bright light (>3 mm and both fixed=1, other or unknown=0) <sup>b</sup>
PaO <sub>2</sub> , mmHg (unknown=0) FiO <sub>2</sub> at the time of PaO <sub>2</sub> if oxygen via ETT or headbox (unknown=0)
Base excess in arterial or capillary blood, mmol/L (unknown=0)
Mechanical ventilation at any time during the first hour in ICU (no=0, yes=1) <sup>c</sup>
Elective admission to ICU (no=0, yes=1) <sup>d</sup>
Recovery from surgery or a procedure is the main reason for ICU admission (no=0, yes=1) <sup>e</sup>
Admitted following cardiac bypass (no=0, yes=1) <sup>f</sup>
High risk diagnosis. Record the number in brackets. If in doubt record 0
(0) None
(1) Cardiac arrest preceding ICU admission <sup>g</sup>
(2) Severe combined immune deficiency
(3) Leukemia or lymphoma after first induction
(4) Spontaneous cerebral hemorrhage <sup>h</sup>
(5) Cardiomyopathy or myocarditis
(6) Hypoplastic left heart syndrome <sup>i</sup>
(7) HIV infection
(8) Liver failure is the main reason for ICU admission <sup>j</sup>
(9) Neuro-degenerative disorder <sup>k</sup>
Low risk diagnosis. Record the number in brackets. If in doubt record 0
(0) None
(1) Asthma is the main reason for ICU admission
(2) Bronchiolitis is the main reason for ICU admission <sup>l</sup>
(3) Croup is the main reason for ICU admission
(4) Obstructive sleep apnea is the main reason for ICU admission <sup>m</sup>
(5) Diabetic ketoacidosis is the main reason for ICU admission

These following rules must be followed carefully for PIM2 to perform reliably: <sup>a</sup>Record SBP as 0 if the patient is in cardiac arrest, record 30 if the patient is shocked and the blood pressure is so low that it cannot be measured; <sup>b</sup>Pupillary reactions to bright light are used as an index of brain function. Do not record an abnormal finding if this is due to drugs, toxins or local eye injury; <sup>c</sup>Mechanical ventilation includes mask or nasal CPAP or BiPAP or negative pressure ventilation; <sup>d</sup>Elective admission. Include admission after elective surgery or admission for an elective procedure (e.g., insertion of a central line), or elective monitoring, or review of home ventilation. An ICU admission or an operation is considered elective if it could be postponed for more than 6 h without adverse effect; <sup>e</sup>Recovery from surgery or procedure includes a radiology procedure or cardiac catheter. Do not include patients admitted from the operating theater where recovery from surgery is not the main reason for ICU admission (e.g., a patient with a head injury who is admitted from theater after insertion of an ICP monitor; in this patient the main reason for ICU admission is the head injury); <sup>f</sup>Cardiac bypass. These patients must also be coded as recovery from surgery; <sup>g</sup>Cardiac arrest preceding ICU admission includes both in-hospital and out-of-hospital arrests. Requires either documented absent pulse or the requirement for external cardiac compression. Do not include past history of cardiac arrest; <sup>h</sup>Cerebral hemorrhage must be spontaneous (e.g., from aneurysm or AV malformation). Do not include traumatic cerebral hemorrhage or intracranial hemorrhage that is not intracerebral (e.g., subdural hemorrhage); <sup>i</sup>Hypoplastic left heart syndrome. Any age, but include only cases where a Norwood procedure or equivalent is or was required in the neonatal period to sustain life; <sup>j</sup>Liver failure acute or chronic must be the main reason for ICU admission. Include patients admitted for recovery following liver transplantation for acute or chronic liver failure; <sup>k</sup>Neuro-degenerative disorder. Requires a history of progressive loss of milestones or a diagnosis where this will inevitably occur; <sup>l</sup>Bronchiolitis. Include children who present either with respiratory distress or central apnea where the clinical diagnosis is bronchiolitis; <sup>m</sup>Obstructive sleep apnea. Include patients admitted following adenoidectomy and/or tonsillectomy in whom obstructive sleep apnea is the main reason for ICU admission (and code as recovery from surgery). PIM: Pediatric index of mortality; ICU: Intensive Care Unit; PaO<sub>2</sub>: Arterial oxygen pressure; FiO<sub>2</sub>: Fraction of inspired oxygen; ETT: Endotracheal tube; CPAP: Continuous positive airway pressure; BiPAP: Bilevel positive airway pressure; AV: Arteriovenous

with acute bronchiolitis (a low-risk diagnosis) would be coded only as having a high-risk diagnosis. (2) SBP is known to have a nonlinear relationship with the risk of mortality; both very high and very low SBP are indicative of poor health status. SBP 120 was included as a predictor, and where SBP was missing, a value of 120 was used. (3) Two transformations for the value of base excess was considered: The absolute value of base excess and base excess as a quadratic function. Where

base excess was missing, a value of zero was used. (4) Four approaches for incorporating PaO<sub>2</sub> and FiO<sub>2</sub> in the model. (4a)  $[(\text{FiO}_2 \times 100)/\text{PaO}_2]$  was calculated in the same manner as PIM2 replacing the ratio with zero if PaO<sub>2</sub> or FiO<sub>2</sub> was missing; (4b) Replacing the ratio with 0.23 if PaO<sub>2</sub> or FiO<sub>2</sub> missing, derived from the normal value of PaO<sub>2</sub> in air  $[(0.21 \times 100)/90]$ ; (4c) The natural logarithm of  $[(\text{PaO}_2/\text{FiO}_2) \times 100]$  replacing the ratio with 430 if PaO<sub>2</sub> or FiO<sub>2</sub> missing; (4d) The absolute

**Table 5: Pediatric index of mortality 3 score**

PIM3 is calculated from the information collected at the time a child is admitted to your ICU

Record the observations at or about the time of first fact-to-face (not telephone) contact between the patient and a doctor from your ICU (or a doctor from a specialist pediatric transport team)

Use the first value of each variable measured within the period from the time of first contact to 1 h after arrival in your ICU. The first contact may be in your ICU, or your emergency department, or a ward in your own hospital, or in another hospital (e.g., on a retrieval)

SBP, mmHg (unknown=120)<sup>a</sup>

Pupillary reactions to bright light (>3 mm and both fixed=1, other or unknown=0)<sup>b</sup>

FiO<sub>2</sub> × 100/PaO<sub>2</sub>, PaO<sub>2</sub> mmHg, FiO<sub>2</sub> at the time of PaO<sub>2</sub> if oxygen via ETT or headbox (FiO<sub>2</sub> or PaO<sub>2</sub> unknown,  $[(\text{FiO}_2 \times 100)/\text{PaO}_2]=0.23$ )

Base excess in arterial or capillary blood, mmol/L (unknown=0)

Mechanical ventilation at any time during the 1<sup>st</sup> hour in ICU (no=0, yes=1)<sup>c</sup>

Elective admission to ICU (no=0, yes=1)<sup>d</sup>

Recovery from surgery or a procedure is the main reason for ICU admission<sup>e</sup>

(0) No

(1) Yes, recovery from a bypass cardiac procedure

(2) Yes, recovery from a non-bypass cardiac procedure

(3) Yes, recovery from a noncardiac procedure

Low-risk diagnosis. Record the number in brackets. If in doubt record 0

(0) None

(1) Asthma is the main reason for ICU admission

(2) Bronchiolitis is the main reason for ICU admission<sup>f</sup>

(3) Croup is the main reason for ICU admission

(4) Obstructive sleep apnea is the main reason for ICU admission<sup>g</sup>

(5) Diabetic ketoacidosis is the main reason for ICU admission

(6) Seizure disorder is the main reason for ICU admission<sup>h</sup>

High-risk diagnosis. Record the number in brackets. If in doubt record 0

(0) None

(1) Spontaneous cerebral hemorrhage<sup>i</sup>

(2) Cardiomyopathy or myocarditis

(3) Hypoplastic left heart syndrome

(4) Neurodegenerative disorder

(5) Necrotizing enterocolitis is the main reason for ICU admission

Very high-risk diagnosis. Record the number in brackets. If in doubt record 0

(0) None

(1) Cardiac arrest preceding ICU admission<sup>j</sup>

(2) Severe combined immune deficiency

(3) Leukemia or lymphoma after first induction<sup>k</sup>

(4) Bone marrow transplant recipient

(5) Liver failure is the main reason for ICU admission<sup>l</sup>

Coding rules. These rules must be followed carefully for PIM3 to perform reliably: <sup>a</sup>Record SBP as 0 if the patient is in cardiac arrest; record 30 if the patient is shocked and the blood pressure is so low that it cannot be measured; <sup>b</sup>Pupillary reactions to bright light are used as an index of brain function. Do not record an abnormal finding if this is due to drugs, toxins, or local eye injury; <sup>c</sup>Mechanical ventilation includes invasive ventilation, mask or nasal CPAP, or BiPAP, or negative pressure ventilation; <sup>d</sup>Elective admission. Include admission (planned or foreseeable) after elective surgery or admission for an elective procedure (e.g., insertion of a central catheter), or elective monitoring, or review of home ventilation. An ICU admission or an operation is considered elective if it could be postponed for more than 6 h without adverse effect; <sup>e</sup>Recovery from surgery or procedure (includes a radiology procedure or cardiac catheter). Do not include patients admitted from the operating theater where recovery from surgery is not the main reason for ICU admission (e.g., a patient with a head injury who is admitted from theater after insertion of an intracranial pressure monitor; in this patient the main reason for ICU admission is the head injury). <sup>f</sup>Bronchiolitis. Include children who present either with respiratory distress or central apnea where the clinical diagnosis is bronchiolitis; <sup>g</sup>Obstructive sleep apnea. Include patients admitted following adenoidectomy and/or tonsillectomy in whom obstructive sleep apnea is the main reason for ICU admission (and code as recovery from surgery); <sup>h</sup>Seizure disorder. Include patients who require admission primarily due to status epilepticus, epilepsy, febrile convulsion, or other epileptic syndrome where admission is required either to control seizures or to recover from the effects of seizures or treatment; <sup>i</sup>Cerebral hemorrhage must be spontaneous (e.g., from aneurysm or arteriovenous malformation). Do not include traumatic cerebral hemorrhage or intracranial hemorrhage that is not intracerebral (e.g., subdural hemorrhage); <sup>j</sup>Hypoplastic left heart syndrome. Any age, but include only cases where a Norwood procedure or equivalent is required in the neonatal period to sustain life; <sup>k</sup>Neurodegenerative disorder. Requires a history of progressive loss of milestones (even if no specific condition has been diagnosed), or a diagnosis where this will inevitably occur; <sup>l</sup>Cardiac arrest preceding ICU admission includes both in-hospital and out-of-hospital arrest. Requires either documented absent pulse or the requirement for external cardiac compression. Do not include past history of cardiac arrest; <sup>m</sup>Leukemia or lymphoma. Include only cases where admission is related to leukemia or lymphoma or the therapy for these conditions. <sup>n</sup>Liver failure, acute or chronic. Must be the main reason for ICU admission. Do not include patients admitted following an elective liver transplant. SBP: Systolic blood pressure; ICU: Intensive Care Unit; PIM: Pediatric Index of Mortality; ETT: Endotracheal tube; CPAP: Continuous positive airway pressure; BiPAP: Bilevel positive airway pressure

value of the difference between the calculated ratio ( $[\text{FiO}_2 \times 100]/\text{PaO}_2$ ) and the normal value (0.23). PIM2 over predicted the risk of mortality in children admitted to ICU in 2010 and 2011.<sup>[18]</sup> Even though, recalibrating the coefficients improved the performance, cardiac bypass no longer predicted mortality, and the prediction was poor among low-risk patients.

### Outcome scores or descriptive scores

Descriptive or Outcome scores which describe the course of illness after the admission into PICU. Multiorgan dysfunction syndrome (MODS) is well described by outcome score. Seven organs have been considered in organ dysfunction namely, respiratory, cardiovascular, neurologic, hematologic, renal, hepatic, and gastrointestinal. Wilkinson *et al.*<sup>[19]</sup> and Proulx *et al.*<sup>[20]</sup> defined the diagnostic criteria of these organ dysfunctions. The diagnostic accuracy of the variables used in these definitions has never been validated, in spite of that; these diagnostic criteria of pediatric MODS are extensively used by practitioners and investigators. In critically ill adults, three quantitative scoring systems estimating the severity of cases of MODS have been developed and validated: The multiple organ dysfunction score,<sup>[21]</sup> the logistic organ dysfunction score,<sup>[22]</sup> and the Sepsis Organ Failure Assessment score.<sup>[23]</sup> There is a direct relationship between the number of organ dysfunctions and the mortality rate in children.<sup>[24]</sup> However, mortality in the ICU is a not only related to the number of failing systems but also the degree of dysfunction of each system. In fact, the predictive weight of the different organ systems is not similar. For example, the cardiovascular and neurologic systems are more predictive of death than hepatic or renal dysfunction. The relative weight and the severity of the organ dysfunction are not taken into account in the MODS score which may cast doubt on its reliability and its usefulness.

### Pediatric logistic organ dysfunction score

Two scores were developed for the assessment of MODS in children in a cohort of 594 patients admitted in three French and Canadian PICUs between January and May 1997.<sup>[24]</sup> Pediatric multiple organ dysfunction (PEMOD) system and PELOD system included one and several variables, respectively. Severity level score of organ dysfunction was graded from 1 to 4 for the PEMOD system and three levels with scores of 1, 10, and 20 for PELOD system. For both systems, calibrations were good ( $P = 0.23$  and  $P = 0.44$ , respectively). The PELOD system was more discriminant than the PEMOD system (AU-ROC curves 0.98 and 0.92, respectively). PELODS was validated by a prospective, observational,

multicenter cohort study in seven multidisciplinary, tertiary care PICUs of university-affiliated hospitals (two French, three Canadian, and two Swiss)<sup>[25]</sup> which included 1806 consecutive patients. PELODS included six organ dysfunctions and 12 variables and was recorded daily for each variable, the most abnormal value each day was used to calculate daily PELOD for first 5 days of stay (dPELOD) and during the whole stay was used to calculate the PELODSs [Table 6]. The discrimination of the PELODS was  $0.91 \pm 0.01$ , and the calibration was good ( $P = 0.54$ ). The discrimination value of the dPELODS was quite good with the AU-ROC curve ranged from 0.79 to 0.85 during first 5 days. PELODS can be used as an outcome measure of clinical trials, the severity of illness of patients treated, a marker of severity of illness in quality assurance and costing studies in PICUs.

PELODS also has its own limitation like treatment bias may be a problem because the PELODS includes data

**Table 6: Pediatric logistic organ dysfunction score**

Organ dysfunction and variable	Scoring system			
	0	I	10	20
<b>Neurological*</b>				
Glasgow coma score	12-15 and	7-11	4-6 or	3
Pupillary reactions	Both reactive	NA	Both fixed	NA
<b>Cardiovascular†</b>				
Heart rate (beats/min)				
< 12 years	< / = 195	NA	> 195	NA
12 years	< / = 150	NA	> 150	NA
<b>SBP (mm Hg)</b>				
< 1 month	> 65	NA	35-65	< 35
1 month-1 year‡	> 75	NA	35-75	< 35
1-12 years‡	> 85	NA	45-85	< 45
12 years	> 95	NA	55-95	< 55
<b>Renal</b>				
Creatinine (mol/L)				
< 7 days	< 140	NA	140	NA
7 days-1 year‡	< 55	NA	55	NA
1-12 years‡	< 100	NA	100	NA
12 years	< 140	NA	140	NA
<b>Respiratory§</b>				
PaO <sub>2</sub> (mmHg)/FiO <sub>2</sub>	> 70	NA	< / = 70	NA
PaCO <sub>2</sub> (mmHg)	< / = 90	NA	> 90	NA
<b>Mechanical ventilation¶</b>				
	No ventilation	Ventilation	NA	NA
<b>Hematological</b>				
White blood cell count (10 <sup>9</sup> /L)	4.5 and	1.5-4.4 or	< 1.5	NA
Platelets (10 <sup>9</sup> /L)	> or = 35	< 35	NA	NA
<b>Hepatic</b>				
Aspartate transaminase (IU/L)	< 950 and	950 or	NA	NA
Prothrombin time# (or INR)	> 60 (< 140)	60 (140)	NA	NA

\*Glasgow coma score: Use lowest value. If patient is sedated, record estimated Glasgow coma score before sedation. Assess patient only with known or suspected acute central nervous system disease. Pupillary reactions: Nonreactive pupils must be > 3 mm. Do not assess after iatrogenic pupillary dilatation; †Heart rate and SBP: Do not assess during crying or iatrogenic agitation; ‡Strictly less than; §PaO<sub>2</sub>: Use arterial measurement only. ¶Percentage of activity: PaO<sub>2</sub>/FiO<sub>2</sub> ratio, which cannot be assessed in patients with intracardiac shunts, is considered as normal in children with cyanotic heart disease. PaCO<sub>2</sub> may be measured from arterial, capillary, or venous samples. Mechanical ventilation: The use of mask ventilation is not counted as mechanical ventilation. PaO<sub>2</sub>: Arterial oxygen pressure; FiO<sub>2</sub>: Fraction of inspired oxygen; PaCO<sub>2</sub>: Arterial carbon dioxide pressure; INR: International normalized ratio; NA: Not available; SBP: Systolic blood pressure

that can be modulated by the care provided during PICU stay. Thus, the PELODS cannot differentiate between the therapy and severity of disease, but this bias is unavoidable unless one is ready to give no treatment to critically ill children for the ideal score which is unethical. PELODS has not been tested in countries other than Canada, France, and Switzerland. PELODS is not validated to predict post-ICU morbidity, and mortality and further studies are required before the PELODS can be used as a surrogate outcome of post-ICU morbidity and mortality.

### Pediatric logistic organ dysfunction score II

PELOD II was designed to update and improve the PELODS, using a larger and more recent dataset of 3671 consecutive patients. Discrimination (AU-ROC 0.934) and calibration (Chi-square test for goodness-of-fit = 9.31,  $P = 0.317$ ) score were good.<sup>[26]</sup> The changes made compared to PELODS was the addition of mean arterial pressure and lactatemia in the cardiovascular dysfunction and removal of hepatic dysfunction [Table 7].

PELOD-2 has its own limitations. Data were collected using the set of 8 days (days 1, 2, 5, 8, 12, 16, and 18, plus the PICU discharge) in PICU that were previously identified as the optimal time points for measurement of dPELOD. Hence, an abnormal value of a variable measured on a day outside this predetermined set of days could be missed. PELOD-2 was developed and validated with a dataset that originated from only two countries (France and Belgium) which are different from other parts of the world population.<sup>[27,28]</sup> Thus, the extrapolation to other countries has to be verified. Interobserver variability was not studied and should be evaluated in future studies on new populations.

### Conclusion

PRISM, PIM, PELOD were very well validated with respect to short-term outcome (death in PICUs). However, these scores (PRISM and PIM) may not be applicable to developing nations like India as it is different from those nations, where these scores were validated. The reasons were resource limitation, different patient characteristics, and inadequate training of the staff. Validation of these scores in developing countries had shown mixed results. Moreover, clinical profile of our patient population includes infections and malnutrition while genetic disorders, trauma constitute major clinical profile in those nations where the scores are developed. Hence, there is high need to design composite scores for developing nations like India, which include variables like malnutrition, resources, etc., No score discussed in this article was validated to predict

**Table 7: Pediatric logistic organ dysfunction score 2**

Organ dysfunctions and variables <sup>a</sup>	Points by severity levels					
	0	1	2	3	4	5 6
<b>Neurologic<sup>b</sup></b>						
Glasgow coma score	≥ 11	5-10			3-4	
Pupillary reaction	Both reactive					Both fixed
<b>Cardiovascularc</b>						
Lactatemia (mmol/L)	<5.0	5.0-10.9			≥ 11.0	
Mean arterial pressure (mm Hg) (months)						
0-<1	≥46		31-45	17-30		≤16
1-11	≥55		39-54	25-38		≤24
12-23	≥60		44-59	31-43		≤30
24-59	≥62		46-61	32-44		≤31
60-143	≥65		49-64	36-48		≤35
≥144	≥67		52-66	38-51		≤37
<b>Renal</b>						
Creatinine (μmol/L) (months)						
0-<1	≤69		≥70			
1-11	≤22		≥23			
12-23	≤34		≥35			
24-59	≤50		≥51			
60-143	≤58		≥59			
≥144	≤92		≥93			
<b>Respiratory<sup>d</sup></b>						
PaO <sub>2</sub> (mm Hg)/FiO <sub>2</sub>	≥61		≤60			
PaCO <sub>2</sub> (mm Hg)	≤58	59-94		≥95		
Invasive ventilation	No			Yes		
<b>Hematologic</b>						
WBC count (×10 <sup>9</sup> /L)	>2		≤2			
Platelets (×10 <sup>9</sup> /L)	≥142	77-141	≤76			

<sup>a</sup>All variables must be collected, but measurements can be done only if justified by the patient's clinical status. If a variable is not measured, it should be considered normal. If a variable is measured more than once in 24h, the worst value is used in calculating the score; <sup>b</sup>Neurologic dysfunction - Glasgow coma score: Use the lowest value. If the patient is sedated, record the estimated Glasgow coma score before sedation. Assess only patients with known or suspected acute central nervous system disease. Pupillary reactions: Nonreactive pupils must be >3 mm. Do not assess after iatrogenic pupillary dilatation; <sup>c</sup>Cardiovascular dysfunction: Heart rate and mean arterial pressure: Do not assess during crying or iatrogenic agitation; <sup>d</sup>Respiratory dysfunction: PaO<sub>2</sub>: Use arterial measurement only. PaO<sub>2</sub>/FiO<sub>2</sub> ratio is considered normal in children with cyanotic heart disease. PaCO<sub>2</sub> can be measured from arterial, capillary, or venous samples. Invasive ventilation: the use of mask ventilation is not considered invasive ventilation. Logit (mortality) = -6.61 + 0.47 × PELOD-2 score; Probability of death = 1 / (1 + exp [-logit (mortality)]); FiO<sub>2</sub>: Fraction of inspired oxygen; PELOD: Pediatric logistic organ dysfunction; PaO<sub>2</sub>: Arterial oxygen pressure; WBC: White blood cell

or to describe long-term outcomes, like mortality or morbidity observed after PICU stay. It is also needed for us to know, the predictors of mortality and morbidity that can be attributed to ICU-related events in children so as to improve the quality of care for sick children.

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### Conflicts of interest

There are no conflicts of interest.

### References

1. Pollack MM. Clinical scoring systems in pediatric intensive care. In: Fuhrmanand BP, Zimmerman JJ, editors. Pediatric Critical Care. Saint Louis, MO, USA: Mosby Year Book; 1992. p. 153-62.



2. Yeh TS, Pollack MM, Ruttimann UE, Holbrook PR, Fields AI. Validation of a physiologic stability index for use in critically ill infants and children. *Pediatr Res* 1984;18:445-51.
3. Pollack MM, Ruttimann UE, Getson PR. Pediatric risk of mortality (PRISM) score. *Crit Care Med* 1988;16:1110-6.
4. Pollack MM, Patel KM, Ruttimann UE. PRISM III: An updated pediatric risk of mortality score. *Crit Care Med* 1996;24:743-52.
5. Tibby SM, Murdoch IA. Calibration of the paediatric index of mortality score for UK paediatric intensive care. *Arch Dis Child* 2002;86:65.
6. Shann F, Pearson G, Slater A, Wilkinson K. Paediatric index of mortality (PIM): A mortality prediction model for children in intensive care. *Intensive Care Med* 1997;23:201-7.
7. Qureshi AU, Ali AS, Ahmad TM. Comparison of three prognostic scores (PRISM, PELOD and PIM 2) at pediatric intensive care unit under Pakistani circumstances. *J Ayub Med Coll Abbottabad* 2007;19:49-53.
8. Choi KM, Ng DK, Wong SF, Kwok KL, Chow PY, Chan CH, *et al.* Assessment of the pediatric index of mortality (PIM) and the pediatric risk of mortality (PRISM) III score for prediction of mortality in a paediatric intensive care unit in Hong Kong. *Hong Kong Med J* 2005;11:97-103.
9. Taori RN, Lahiri KR, Tullu MS. Performance of PRISM (Pediatric Risk of Mortality) score and PIM (Pediatric Index of Mortality) score in a tertiary care pediatric ICU. *Indian J Pediatr* 2010;77:267-71.
10. Thukral A, Lodha R, Irshad M, Arora NK. Performance of pediatric risk of mortality (PRISM), pediatric index of mortality (PIM), and PIM2 in a pediatric intensive care unit in a developing country. *Pediatr Crit Care Med* 2006;7:356-61.
11. Pollack MM, Patel KM, Ruttimann UE. The pediatric risk of mortality III – Acute physiology score (PRISM III-APS): A method of assessing physiologic instability for pediatric intensive care unit patients. *J Pediatr* 1997;131:575-81.
12. Dragsted L, Jørgensen J, Jensen NH, Bönsing E, Jacobsen E, Knaus WA, *et al.* Interhospital comparisons of patient outcome from intensive care: Importance of lead-time bias. *Crit Care Med* 1989;17:418-22.
13. Slater A, Shann F, Pearson G; Paediatric Index of Mortality (PIM) Study Group. PIM2: A revised version of the paediatric index of mortality. *Intensive Care Med* 2003;29:278-85.
14. Eulmesekian PG, Pérez A, Mincez PG, Ferrero H. Validation of pediatric index of mortality 2 (PIM2) in a single pediatric intensive care unit of Argentina. *Pediatr Crit Care Med* 2007;8:54-7.
15. Ng DK, Miu TY, Chiu WK, Hui NT, Chan CH. Validation of pediatric index of mortality 2 in three pediatric intensive care units in Hong Kong. *Indian J Pediatr* 2011;78:1491-4.
16. Imamura T, Nakagawa S, Goldman RD, Fujiwara T. Validation of pediatric index of mortality 2 (PIM2) in a single pediatric intensive care unit in Japan. *Intensive Care Med* 2012;38:649-54.
17. Sankar J, Singh A, Sankar MJ, Joghee S, Dewangan S, Dubey N. Pediatric index of mortality and PIM2 scores have good calibration in a large cohort of children from a developing country. *Biomed Res Int* 2014;2014:907871.
18. Straney L, Clements A, Parslow RC, Pearson G, Shann F, Alexander J, *et al.* Paediatric index of mortality 3: An updated model for predicting mortality in pediatric intensive care\*. *Pediatr Crit Care Med* 2013;14:673-81.
19. Wilkinson JD, Pollack MM, Ruttimann UE, Glass NL, Yeh TS. Outcome of pediatric patients with multiple organ system failure. *Crit Care Med* 1986;14:271-4.
20. Proulx F, Fayon M, Farrell CA, Lacroix J, Gauthier M. Epidemiology of sepsis and multiple organ dysfunction syndrome in children. *Chest* 1996;109:1033-7.
21. Marshall JC, Cook DJ, Christou NV, Bernard GR, Sprung CL, Sibbald WJ. Multiple organ dysfunction score: A reliable descriptor of a complex clinical outcome. *Crit Care Med* 1995;23:1638-52.
22. Le Gall JR, Klar J, Lemeshow S, Saulnier F, Alberti C, Artigas A, *et al.* The logistic organ dysfunction system. A new way to assess organ dysfunction in the intensive care unit. ICU Scoring Group. *JAMA* 1996;276:802-10.
23. Vincent JL, Moreno R, Takala J, Willatts S, De Mendonça A, Bruining H, *et al.* The SOFA (Sepsis-related Organ Failure Assessment) score to describe organ dysfunction/failure. On behalf of the Working Group on Sepsis-Related Problems of the European Society of Intensive Care Medicine. *Intensive Care Med* 1996;22:707-10.
24. Leteurte S, Martinot A, Duhamel A, Gauvin F, Grandbastien B, Nam TV, *et al.* Development of a pediatric multiple organ dysfunction score: Use of two strategies. *Med Decis Making* 1999;19:399-410.
25. Leteurte S, Martinot A, Duhamel A, Proulx F, Grandbastien B, Cotting J, *et al.* Validation of the paediatric logistic organ dysfunction (PELOD) score: Prospective, observational, multicentre study. *Lancet* 2003;362:192-7.
26. Leteurte S, Duhamel A, Salleron J, Grandbastien B, Lacroix J, Leclerc F; Groupe Francophone de Réanimation et d'Urgences Pédiatriques (GFRUP). PELOD-2: An update of the Pediatric logistic organ dysfunction score. *Crit Care Med* 2013;41:1761-73.
27. Marcín JP, Song J, Leigh JP. The impact of pediatric intensive care unit volume on mortality: A hierarchical instrumental variable analysis. *Pediatr Crit Care Med* 2005;6:136-41.
28. Leteurte S, Grandbastien B, Leclerc F, Parslow R; Groupe Francophone de Réanimation et Urgences Pédiatriques, Paediatric Intensive Care Audit Network. International comparison of the performance of the paediatric index of mortality (PIM) 2 score in two national data sets. *Intensive Care Med* 2012;38:1372-80.