Original Article

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Paediatrics Section

Comparison of PRISM III and PIM II Score in Predicting Mortality in Paediatric Intensive Care Unit: An Observational Study

V MUTHUPANDI[1], R DIANAGRACE[2], E NARAYANAN[3], J SATHYA[4]

ABSTRACT

Introduction: Prognostic scores play a vital role in predicting the outcome of children admitted in Paediatric Intensive Care Unit (PICU) thereby reducing the mortality. For paediatric population, Paediatric Risk of Mortality (PRISM III) and Paediatric Index of Mortality (PIM II) are the principal scores. As limited PICU beds are available in many tertiary care centres, PRISM III score helps in predicting mortality risk and admission to PICU.

Aim: To compare PRISM III and PIM II in predicting the mortality in sick children in a PICU and their relation between observed and predicted mortality.

Materials and Methods: This was a prospective observational study, conducted in Chengalpattu Medical College Hospital, Chennai, Tamil Nadu, India, from July 2018 to June 2019 that enrolled 102 children who were admitted to PICU. At first hour of admission, PIM II score was assessed and at 24 hours of admission, PRISM III score was assessed and the mortality was predicted. Children were followed-up until discharge or death, and the predicted mortality was compared with actual mortality and validation of scores was done using Statistical Package for the Social Sciences (SPSS) version 16.0.

Results: Mean age of the population was 37.6 months, and majority of the children were aged less than 12 months. Male children were predominant (52%). Major system involvement was respiratory system 38 (37.3%) and mortality was 18 (17.6%). The mean score for death in PRISM III and PIM II were 11.8 and 19.9, respectively. The mean score for survival in PRISM III and PIM II were 4.4 and 9, respectively. Total PRISM III and PIM II score was lower in children who survived and mortality has been observed with higher scores. On comparison, PRISM III score was better to predict the mortality than PIM II. The Area Under Curve (AUC) and sensitivity for PRISM III score were 0.881 with 95% CI (0.769 to 0.992) and 94.44% respectively versus the AUC and sensitivity for PIM II score were 0.768 with CI (0.628 to 0.908) and 61.11%, respectively. Using logistic regression, risk of mortality was analysed and found that increase in one score has 0.62 times the increased risk of death in PRISM III score and thus, it predicts the mortality better.

Conclusion: The PRISM III score was better than PIM II score for risk stratification and to optimise available limited resources. Both scores underestimate the predicted mortality in comparison to observed mortality.

Keywords: Mortality scores, Paediatric index of mortality, Paediatric risk of mortality, Prediction, Scoring system

INTRODUCTION

The PICU is a specialised area which takes care of critically ill infant and children. As predicting the outcome at earlier stages is difficult, prognostic scores helps in predicting the outcome as early as possible and helps to prognosticate groups of patients with similar presentation of illness [1]. For paediatric population, PRISM III and PIM II are the principal scores [2]. Most recent versions are PRISM III and PIM II. In view of predicting mortality, PRISM III score is effective. Studies showing PRISM III score predictive value is limited in many countries other than America and Europe. In hospitals with limited PICU beds, PRISM III score often helps the paediatricians to predict mortality risk and decide which patients need admission to PICU. Severity of illness scoring systems could be used to quantify the severity of illness, to assess the Intensive Care Unit (ICU) performance and compare the quality of different ICUs, to assess the impact on patient outcomes of planned changes in ICU, to assess the prognosis of children in order to counsel the families and caretakers. Finally, it also helps to evaluate suitability of children for novel therapy [3].

The PRISM III has been developed from Physiologic Stability Index (PSI) which originally contains 34 variables [4]. The PRISM III has been modified into three generations. PRISM III has 17 physiological variables which contain both clinical and laboratory parameters [Table/Fig-1]. The PIM II is now widely accepted, updated score against other standard scores. In view of predicting the mortality, PIM II actually differs from original PRISM III score in which the variables are reduced in number and easy to use in intensive care settings. The PIM II resulted in several improvements over original PRISM III score [5]. Reassessment of physiologic variables and their ranges, better age adjustment for selected variables and additional risk factors resulted in a mortality risk model that discriminates better [5]. Recent studies analysed the validity of PRISM III and has shown that PRISM III score at 12 and 24 hours has high sensitivity and specificity with AUC was 0.875 (CI: 0.813-0.937) and 0.905 (CI:0.844-0.967), respectively [6-8].

The PIM II score was introduced by Slater A and Shann F in 1997 (updated in 2003) and it is easier to collect data from large number of patients when compared to PRISM III score. The PIM II score has been better validated in Australia and New Zealand [9]. Only very few studies are available from developing countries. The PIM II score has few variables compared to PRISM III score, hence it is easy to collect data and to study on large population. Advantage of PIM II score over PRISM III was its ease of use and that it can be performed within one hour of admission, resulting in early identification of severity of illness for necessary intervention.

A	Cardiovascular and neurological	Findings		Points
1.	Systolic blood pressure (mmHg)	Infant	>65	0
			45-65	3
			<45	7
		Children	>75	0
			55-75	3
			<55	7
2.	Heart rate (bpm)	Infant	<215	0
			215-225	3
			>225	4
		Children	<185	0
			185-205	3
			>205	4
3.	Temperature (degree celsius)	<33		3
		33-40		0
		>40		3
4.	Mental status (GCS)	>8		0
		<8		5
5.	Pupillary response	Both reactive		0
		One reactive and one fixed		7
		Both fixed		11
B	**Acid base blood gases**	**Findings**		**Points**
1.	Acidosis	pH >7.28 and Total CO_2 ≥7 mEq/L		0
		pH - 7.0 to 7.28 and Total CO_2 5-7 mEq/L		2
		pH <7.0 and Total CO_2 <5 mEq/L		6
2.	PCO_2 (mmHg)	<50		0
		50-75		1
		>75		3
3.	Total CO_2 (mEq/L)	≤34		0
		>34		4
4.	$PaCO_2$ (mmHg)	≥50		0
		42-49.9		3
		<42		6
C	**Biochemistry**	**Findings**		**Points**
1.	Glucose (mg/dL)	≤200		0
		>200		2
2.	Potassium (mEq/L)	≤6.9		0
		>6.9		3
3.	Creatinine (mg/dL)	≤0.9		0
		>0.9		2
4.	BUN (mg/dL)	≤14.9		0
		>14.9		3
D	**Haematological test**	**Findings**		**Points**
1	White cell count	≥3000		0
		<3000		4
2	Platelet count	>200000		0
		100000-200000		2
		50000-100000		4
		<50000		5
3	Prothrombin time and activated partial thromboplastin clotting time (seconds)	≤22 and ≤57		0
		>22 and >57		3

[Table/Fig-1]: Parameters of PRISM III score.

The PIM II score has 10 physiological variables. Parameters of PIM II score are shown in [Table/Fig-2]. The PIM II score was well-discriminated and both the scores are well-validated for short-term outcome in PICU [5]. Most of the severity scores were designed at Western countries and need to be validated in India. The PIM II score has less number of variables when compared with PRISM III score which includes both clinical and laboratory parameters that is time consuming. The aim of this study was to compare PRISM III and PIM II in predicting the mortality in sick children in a PICU and their relation between observed and predicted mortality.

1	Systolic blood pressure, mmHg (unknown=120)
2	Pupillary reaction to bright light (>3mm and both fixed=1, other and unknown=0)
3	PaO_2, FiO_2 at the time of PaO_2 if oxygen via ETT or head box
4	Base excess in arterial or capillary blood, mmol/L (Unknown=0)
5	Mechanical ventilation at any time during the first hour in ICU admission.
6	Elective admission to ICU
7	Recovery from surgery or a procedure is the main reason for ICU admission
8	Admitted following cardiac bypass
9	High risk diagnosis
10	Low risk diagnosis

[Table/Fig-2]: Parameters of PIM II score.

MATERIALS AND METHODS

This prospective observational study was conducted in Chengalpattu Medical College Hospital, Chennai, Tamil Nadu, India, from July 2018 to June 2019. Total 102 children who were admitted in PICU were enrolled in the study. This is a 10 bedded, well-equipped unit with mechanical ventilators, 24 hours laboratory facilities, portable bedside X-rays, bedside echocardiogram and ultrasound, all electronic monitors and Arterial Blood Gas Analyzer Machine. Approval for the study was obtained from Institutional Ethical Committee (ECR/774/INST/TN/2015). Sample size needed was 97 assuming a population proportion of 66% with 80% power [10].

Inclusion criteria: All children with age group of one month to 12 years admitted in PICU, as per Indian Academy of Paediatrics (IAP) guidelines-admission for PICU level 3 care were included [11].

Exclusion criteria: Trauma cases, those who left against medical advice and the outcome was not known and children who died within 24 hours of admission were excluded from the study.

Demographic data were collected from all study participants, including age, sex after obtaining parental informed consent. Within the first hour of admission detailed systemic examination was done, and PIM II score was filled in predesigned proforma. Further at 24 hours of admission, PRISM III score was assessed and filled in the proforma. Thus children were investigated and treated as per protocol of the unit.

STATISTICAL ANALYSIS

Data was entered in Excel format analysis using SPSS software (version 16.0). The PIM II scores were computed by QXMD software and converted to predicted mortality. The PRISM III scores were calculated manually by summating all scores of variables in PRISM III and converted to predicted mortality by logistic regression. Children were followed-up until discharge or death. Duration of hospital stay and final diagnosis were also documented during follow-up. The outcome was categorised as survival or death. The association between study variables were analysed by Chi-square test. Age and duration of hospital stay were expressed in mean±standard deviation. Hosmer Lemeshow test was used for the aptness of the test to test the relationship between observed mortality and predicted mortality. The capacity for discrimination between survivors and non survivors was made using Receiver

Operating Curve (ROC curve). Area under the curve near one was taken as significant. Logistic regression analysis was done for both the scores and risk of mortality was analysed.

RESULTS

Among 2300 children admitted in PICU in the last one year, 102 children were enrolled in this study. Children were categorised into two groups according to outcome as survival and death.

The mean age in the study population was 37.6 months and infants constituted around 50% and their outcome was better (51.2%), when compared to older children (22.6%). The age and gender-wise comparison did not show any significant difference between the groups. Length of hospital stay was more among survivors (9.62±4.849 days) than non survivors (4.28±4.226 days). The major primary system involvement was respiratory system 38 (37.3%) followed by central nervous system 30 (29.4%) and cardiovascular system 4 (3.9%) [Table/Fig-3].

Parameters		Total N=102	Died n=18	Survived n=84	p-value
Age (months)	≤12	51 (50%)	8 (44.4%)	43 (51.2%)	0.329
	13-60	26 (25.5%)	7 (38.9%)	19 (22.6%)	
	>60	25 (24.5%)	3 (16.7%)	22 (26.2%)	
Gender	Male	53 (52%)	6 (33.3%)	47 (56%)	0.081
	Female	49 (48%)	12 (66.7%)	37 (44%)	
System	CVS	4 (3.9%)	1 (5.6%)	3 (3.6%)	0.521
	RS	38 (37.2%)	4 (22.2%)	34 (40.4%)	
	CNS	30 (29.4%)	6 (33.3%)	24 (28.6%)	
	Sepsis	30 (29.4%)	7 (38.8%)	23 (27.3%)	
No. of hospital days		6.95±4.537	4.28±4.226	9.62±4.849	0.586

[Table/Fig-3]: Descriptive data comparison of survival and death.
CVS: Cardiovascular system; RS: Respiratory system; CNS: Central nervous system
Among 102 children included in the study, 18 (17.6%) children died

PRISM III and PIM II Score Analysis

The mean score for death in PRISM III and PIM II were 11.8 and 19.9 respectively, as compared to the mean score for survival in PRISM III and PIM II (4.4 and 9 respectively). With scores less than 15, the mortality predicted were 14% and 10% in PRISM III and PIM II score, respectively. With scores more than 15, the mortality predicted was 100% and 48% in PRISM III and PIM II score, respectively. Thus, PRISM III and PIM II scores were lower in children who survived than those who died.

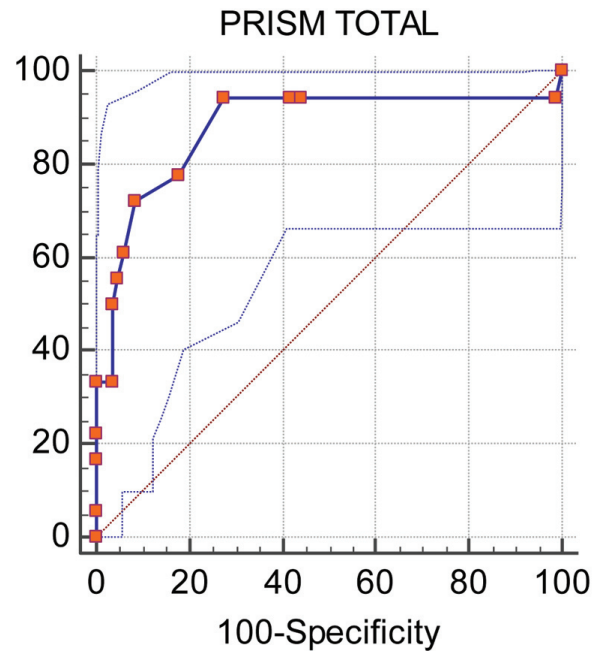
The AUC was 0.881 (CI-0.769 to 0.992) for PRISM III score and p-value was <0.0001 and the sensitivity was 94.44% [Table/Fig-4]. Hence, the PRISM III score predicts well the survival and mortality among the children admitted in PICU as demonstrated by ROC curve [Table/Fig-5]. The PRISM III score variables those predicting the death were PRISM III four and PRISM III seven while others are not able to accurately predict the death.

Parameters	PRISM III score	PIM II score
Sensitivity	94.44%	61.11%
Specificity	72.62%	84.52%
95% Confidence interval	0.769 to 0.992	0.628 to 0.908
Area under ROC curve	0.881	0.768

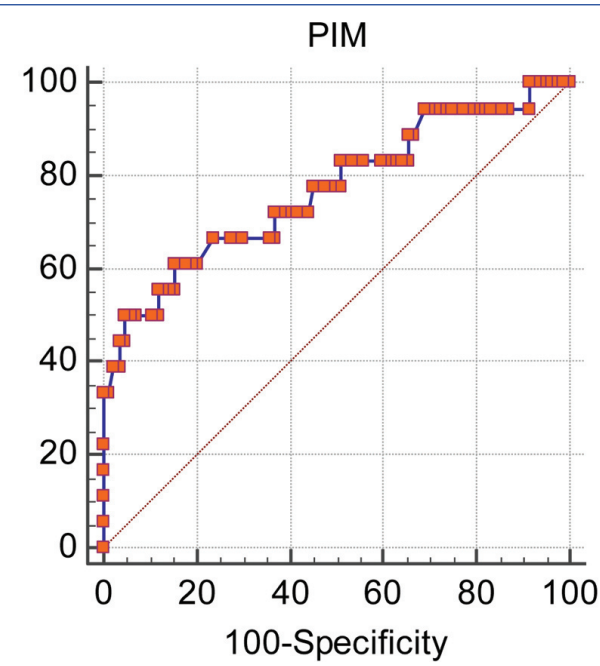
[Table/Fig-4]: Efficacy of scores.

The PIM II score predicted seven deaths out of total eighteen observed deaths, as analysed by binary logistic regression. The AUC was 0.768 (CI-0.628 to 0.908) and sensitivity was 61% [Table/Fig-4,6].

As per binary logistic regression analysis, the predicted mortality was 50% in PRISM III score and 38% in PIM II score, respectively. With increase in every score, PRISM III score showed 0.62 times the increased risk of mortality. Both scores are under predicting the mortality and on comparing both the scores PRISM III score was better to predict the survival and mortality.



[Table/Fig-5]: ROC for PRISM III score.



[Table/Fig-6]: ROC for PIM II score.

DISCUSSION

Children admitted in PICU mostly have high risk of mortality due to multiorgan failure. Appropriate test to predict the mortality is useful. The principal scores used in paediatric population are PRISM III and PIM II scores. In this study, the PRISM III and PIM II score performances were compared in view of predicting mortality.

In this study, 102 children were included and observed mortality was of 18 (17.6%). But both the scores underestimated the mortality; the predictive mortality was 50% as per PRISM III and 38.9% as per PIM II score. Leteurte S et al., and Niederwanger C et al., also demonstrated the underprediction of mortality with PRISM III score as compared to PIM II and PELOD score [12,13]. A Korean study showed the predictive mortality rate of

13.9% and with 14.1% using PIM II and PRISM III respectively versus the observed mortality of 14% [8]. Mean age of the study population was 37.6 months. Total 12 female children died out of 49 admissions and 6 male children died out of 53 admissions. The most affected organ in terms of underlying disease at the time of admission was respiratory system 37.2%, in which the mortality was contributed more by central nervous system (33.3%) and these observations were confirmed by Ozer EA et al., [14]. The proportion of children presenting with sepsis were predominant. Mean length of hospital stay was 6.95±4.537 and maximum stay leads to survival.

In this study, age showed no significant influence on outcome and mortality and similar observations were noted by Raghavendra BYJ et al., where majority of the study population was contributed by children between age group 3 to 18 years [15]. Similar results were also observed by Abdelkader A et al., where PRISM III and PIM II scores had been applied to children and majority of population were between 2 to 12 years [16]. Similarly, gender did not show influence on outcome which were also noted by Khilnani P et al., and Thukral A et al., [11,17]. Among the children admitted, infants constituted 50% (51) and the mortality in infants were 44.4% (8) which is better when compared with older children.

The discriminatory power was analysed using ROC, with PRISM III (AUC being 0.881) having better power than PIM II (AUC being 0.768) with significant correlation (p<0.0001). These were similar to the observations noted by Qureshi AU et al., where the area under ROC for PRISM III was 0.88 followed by 0.78 for PIM II score [18]. Thukral A et al., contradicted these observations, since it showed a poor discriminatory power (AUC for PRISM III was 0.80 and AUC for PIM II was 0.81) [17].

Hosmer Lemeshow goodness of fit test showed that PRISM IV and PRISM VII variables have a good discriminatory capacity on analysing survival and mortality which is shown in [Table/Fig-7] [10]. It is similar to the observation noted by Martha VF and Ramos Garcia PC, where the Hosmer Lemeshow test gave a Chi-square of 9.23 (p-value=0.100) for PRISM III and 27.986 (p-value <0.001) for PIM II [19]. Similar observations are noted in a study by Hwang HS et al., which showed that poor calibration regarding probability values of death [20]. The PIM II score is useful in predicting risk stratification earlier but it is now very much influenced by prehospital management. The PIM II score is not a factor applied for organ dysfunction causing death. The PRISM III score consists of variables like clinical and laboratory parameters, that shows diverse organ dysfunction. In majority, PRISM III score is really diagnosing death rather than predicting death [21]. Both scores are useful in risk stratification while analysing death in various systems as shown in PIM II Score-Bilogistic regression analysis [19] [Table/Fig-8]. On comparing the estimated mortality rate with actual mortality rate, both scores is predicting death lower than the actual mortality rate.

Steps (Variables)	Died		Survived		Total
	Observed	Expected	Observed	Expected	
1	6	7.869	3	1.131	9
2	7	4.488	4	6.512	11
3	1	1.640	8	7.360	9
4	3	1.350	8	9.650	11
5	0	0.969	12	11.031	12
6	0	0.104	2	1.896	2
7	1	1.58	47	46.42	48

[Table/Fig-7]: Contingency table for Hosmer-Lemeshow test for PRISM III.

Steps (Variables)	Died		Survived		Total
	Observed	Expected	Observed	Expected	
1	7	7.228	3	2.712	10
2	3	2.993	7	7.007	10
3	2	2.025	10	9.975	10
4	0	1.281	10	8.719	10
5	2	1.031	8	8.969	10
6	1	0.912	9	9.088	10
7	1	0.799	9	9.201	10
8	1	0.660	9	9.340	10
9	0	0.643	12	11.357	12
10	1	0.368	7	7.632	8

[Table/Fig-8]: PIM II Score-Bilogistic regression analysis.

Limitation(s)

There are few limitations of PRISM III score. Since, it is a time-consuming process and a parent has to spend money for investigations to obtain this score, it is difficult for resource limited ICUs. Rather than predicting death, these scores identify the severity only at the time of death since, it is done at 24 hours of admission.

CONCLUSION(S)

The PRISM III and PIM II scores showed good discriminatory capacity among the survivors and non survivors but revealed poor calibration. The reason behind this may be the different patient profile, delayed referral and poor prehospital management and ultimately load of sick cases managed with less resources etc. The clinical assessment of severity of illness is not always uniform and it is mostly related to the efficiency and experience of the treating doctor and also all children does not respond to the treatment in a similar way.

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PARTICULARS OF CONTRIBUTORS:
1. Assistant Professor, Department of Paediatrics, Theni Medical College, Theni, Tamil Nadu, India.
2. Assistant Professor, Department of Paediatrics, Chengalpattu Medical College, Chennai, Tamil Nadu, India.
3. Assistant Professor, Department of Paediatrics, Chengalpattu Medical College, Chennai, Tamil Nadu, India.
4. Professor, Department of Paediatrics, Chengalpattu Medical College, Chennai, Tamil Nadu, India.

NAME, ADDRESS, E-MAIL ID OF THE CORRESPONDING AUTHOR:
R Dianagrace,
Assistant Professor, Department of Paediatrics, Chengalpattu Medical College,
F4 Holynrn Arcade, No. 3. Valmigi Street, Tambaram, Chennai, Tamil Nadu, India.
E-mail: dianasuji@yahoo.com

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