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RESEARCH

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Effectiveness of PRISM III score in predicting the severity of illness and mortality of children admitted to pediatric intensive care unit: a cross-sectional study

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Abstract

Background The facilities for intensive care are improving day by day in all departments including pediatrics, and prognostication has always been the duty of a physician. Scoring systems are useful to objectively measure the severity and predict the prognosis of sick children. This study was done to assess the severity of illness and mortality risk using the PRISM score in children aged 1 month–18 years, admitted into the pediatric intensive care unit in a tertiary-level hospital. Ninety children of age group 1 month–18 years admitted to the pediatric intensive care unit, satisfying the inclusion and exclusion criteria, were selected after obtaining consent from the parents. A careful history, physical examination, systemic examination, and relevant blood investigations were performed and documented based on the Pediatric Risk Mortality score (PRISM). The relationship between the total prism score obtained and the outcome in terms of mortality, and severity based on the need for either ventilator support or inotrope support or ICU stay of more than 5 days, was studied using appropriate statistical tools.

Results The male to female ratio was 53.3% and 46.7%, with a mortality of 10% and severity of 24%. The average value of the PRISM score was 12 to predict mortality, with 100% sensitivity and 91% specificity. PRISM score of 7 had 100% sensitivity and 95% specificity in predicting severe illness. There was a significant association between a low Glasgow coma scale, pupillary reaction, low systolic blood pressure, acidosis, high blood glucose level, and high serum creatinine with the severity of illness.

Conclusions The present study demonstrates that Pediatric Risk Mortality score III (PRISM III) acts as an excellent discriminative tool for predicting both mortality and severity of illness of children admitted to the pediatric intensive care unit. The area under the ROC curves was 99% for both. As the PRISM score increases, both mortality risk increases and the risk of severity of illness also increases.

Keywords Pediatric risk mortality score, PRISM III score, Sick children, Pediatric intensive care unit, Mortality prediction

Background

Intensive care facilities need to be evaluated, just like every other aspect of health care. The clinical effectiveness of any treatment or intervention must be studied to assess the results. Measurements of morbidity, mortality, disability, function, and quality of life can be used to evaluate the outcome. Deaths are a sensitive and useful

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measure for predicting mortality in critical care units. These rating scales are employed to assess the effectiveness of treatment and its results [1, 2].

Pediatric critical care has historically employed sickness severity metrics. The Pediatric Risk of Mortality score, which is physiologically based and used to measure physiologic status, can be used to calculate the expected mortality risk and expected morbidity risk when paired with additional independent variables. Although recent Pediatric Risk of Mortality data collection enhancements have been made to adapt to new practice patterns, decrease bias, and reduce potential sources of error, the physiologic ranges for the Pediatric Risk of Mortality variables have not altered. These include modifying the Pediatric Risk of Mortality data collection period for patients admitted for "optimizing" care prior to cardiac surgery or interventional catheterization, shortening the data collection period, and changing the outcome to hospital survival/death for the first PICU admission only [2].

PRISM III (Pediatric Risk of Mortality III), a new pediatric physiology-based index for mortality risk, has been created. Thirty-two PICUs worked on developing this. The most aberrant values from the first 24 h of the PICU hospitalization were included in the physiological data. Additionally, outcome and descriptive data were examined. Age-based stratification of the variables (neonate, infant, and child, adolescent). Data from 543 fatalities and 11,165 PICU hospitalizations were gathered. There are 26 ranges for each of the 17 physiological variables in PRISM III. For several factors, PRISM III has a better age adjustment. The results of the analysis showed that the 12-h and 24-h ratings do not differ in their ability to predict death.

Pediatric critical care has long employed indices of illness severity [2–4]. The Pediatric Risk of Mortality (PRISM) score uses 17 regularly measured physiological variables and their ranges to quantify the severity of the disease. The PRISM score quantifies physiologic status using ranges of physiological factors that have been specified and uses categorical variables to enable precise assessment of mortality risk. PRISM is frequently used to adjust for sickness severity in studies and to evaluate the quality of care using standardized mortality ratios (SMRs) [5].

Another scoring system PIM-Pediatric Index of Mortality was put forth by Shann et al. [6]. Systems of scoring that offer a precise assessment of the illness's severity and, as a result, help to forecast patients' prognoses. They are helpful for clinical trial patient comparisons and medical audits as well. The management of resources can also benefit from a grading system. It offers an index for the level of intervention appropriate for a specific patient and can be used to allocate restricted PICU facilities. Therefore, research that can assess the level of treatment and outcomes for patients hospitalized to the pediatric critical care unit is necessary. One of the most recent pediatric mortality rating systems is the PRISM III score.

The PRISM scoring system gives healthcare administrators a perspective on patient prognosis and aids in subsequent patient management decision-making. The ability to anticipate mortality risk will be a helpful tool for intensivists to counsel parents and allocate resources. In tertiary PICUs in most industrialized nations, the PRISM score can be developed and confirmed, but only a small number of reports come from India. The current study aimed to see how useful the PRISM score is in predicting disease severity and mortality in pediatric patients admitted to an intensive care unit at a tertiary-level hospital in Kerala.

Methods

This cross-sectional study was done to assess the severity of illness and mortality risk using PRISM score in children aged 1 month–18 years admitted in a pediatric intensive care unit in a tertiary-level hospital. Ninety children of age group 1 month–18 years admitted to PICU were included, after obtaining consent from the parents. The patients excluded from the study were postoperative children, children with malignancy, and those discharged from PICU in less than 24 h. Demographic details, diagnosis, duration of PICU stay, and outcome were recorded. A careful history, physical examination, systemic examination, and relevant blood investigations were performed and documented. For PRISM 111 score, the variable-systolic blood pressure, heart rate, temperature, mental status, pupillary response, acidosis, pH, pCO_2, PaO_2, glucose, potassium, creatinine, BUN, WBC count, platelet count, prothrombin time, and partial thromboplastin time were recorded within 24 h of PICU admission by the same investigator and the PRISM score was calculated. The relationship between the total prism score obtained and the outcome in terms of mortality, and severity based on the need for either ventilator support or inotrope support or ICU stay of more than 5 days, were studied using an appropriate statistical tool.

Sample size estimation

The sample size was calculated based on a previous study. (Reference research article by Dr: Ashish Varma et al., Department of Pediatrics, JN MC, Sawangi, Wardha, Maharashtra, India. Published on the International Journal of Contemporary Pediatrics on March 2017).

$$n = Z^2 1-\alpha/2 \,\text{sensitivity}\, x(1-\text{sensitivity})\, d^2\, x\, \text{prevalence}$$

$$Z_{1\text{-}\alpha/2} = 1.96 \text{ (at 5\% } \alpha)$$

Table 1 Age-wise distribution for PRISM scoring chart taken from Pollack et al. [7]

0–less than 1 month	Neonate
1 month–12 month	Infant
More than 12–144 months (about 12 years)	Child
More than 144 months (about 12 years)	Adolescent

Sensitivity—93% and prevalence of mortality—12.5% d—precision (15%)

Number of subjects needed = 90

PRISM scoring chart from Pollack et al.[7]

PRISM III has 17 physiological variables.

Age group [7]

Heart rate should not be monitored during crying. Pupillary size should not be assessed after iatrogenic dilatation. Body temperature recorded as axillary temperature. Mental status should not be scored within 2hours of sedation or anesthesia.

Tables 1, 2, 3, 4 and 5 is the PRISM III scoring chart taken from Pollack et al. [7].

Table 2 Cardiovascular and neurological vital signs [7]

Systolic blood pressure	Infant > 65 mmHg	0
	45–65	3
	< 45	7
	Child > 75	0
	55–75	3
	< 55	7
	Adolescent > 85	0
	65–85	3
	< 65	7
Heart rate	Infant < 215beats/minute	0
	215–225	3
	> 225	4
	Child < 185	0
	185–205	3
	> 205	4
	Adolescent < 145	0
	145–155	3
	> 155	4
Temperature	< 33 degree Celsius	3
	33–40	0
	> 40	3
Mental status	Glasgow coma scale > / = 8	0
	Glasgow coma scale < 8	5
Pupillary response	Both reactive	0
	One reactive and fixed > 3 mm	7
	Both fixed > 3 mm	11

Table 3 Acid base and blood gas parameters [7]

Acidosis	PH > 7.28 TCO2 > 17 mEq/L	0
	PH7-7.28 TCO_2 5-16.9	2
	PH < 7 TCO_2 < 5	6
PH	< 7.48	0
	7.48–7.55	2
	> 7.55	3
PCO_2	< 50 mmHg	0
	50–75 mmHg	1
	> 75	3
Total CO_2	< / = 34 mEq/L	0
	> 34 mEq/L	4
PaO_2	> / = 50 mmHg	0
	42–49.9	3
	< 42	6

$$\text{Total PRISM score} = \text{cardiovascular and neurological subscore} + \text{acid base blood gas sub score} + \text{chemistry sub score} + \text{hematology subscore}$$

Interpretation-

1. Minimum subscore and total score 0
2. Maximum cardiovascular and neurological score—30
3. Maximum acid base and blood gas score = 22
4. Maximum chemistry sub score = 10
5. Maximum hematology sub score = 12
6. Maximum total PRISM III score = 75

Results

Socio demographic data of study subjects

Ninety patients participated in the study, among them, 22 were infants (those who were less than 1 year), 28 were children (between 1 and 10 years of age—excluding 10)

Table 4 Chemistry tests [7]

Glucose	< / = 200 mg/L	0
	> 200 mg/dl	2
Serum potassium	< / = 6.9 mEq/L	0
	> 6.9 mEq/L	3
Creatinine	Infant < / = 0.9 mg/dl	0
	> 0.9 mg/dl	2
	Child < / = 0.9 mg/dl	0
	> 0.9 mg/dl	2
	Adolescent < / = 1.3 mg/dl	0
	> 1.3 mg/dl	2
BUN	< / = 14.9 mg/dl	0
	> 14.9 mg/dl	3

Table 5 Hematology tests [7]

Total WBC count	>/=3000	0
	<3000	4
Platelet count	2lac/microliter	0
	1 lac–2lac	2
	50,000–99,999	4
	<50,000	5
PT and PTT	PT (<22 s) and PTT </=57 s	0
	PT>22 and PTT>57 s	3

Table 6 Association between PRISM III score and mortality

NPS<12	75	0	75
NPS>12	6	9	15
	81	9	90

and were adolescents, i.e., Those who aged 10 years and above. Forty-two were females, and 48 were males.

PRISM score in predicting mortality

The results of this study suggest that the PRISM III score predicted mortality rate and the actual observed mortality rate are highly associated, providing a reliable indication of the prognosis and outcome of patients admitted to PICU. According to our study, higher PRISM scores among PICU patients who have been admitted are linked to higher mortality. We also studied the association between the age, gender, systems involved, systolic blood pressure, acidosis, serum potassium, serum creatinine, blood glucose, GCS, and pupillary reaction with outcomes severity and mortality. Using Fisher's exact test, it was found that all parameters except age, gender, and serum potassium level had a significant association, and the *p* value was less than 0.05 (Table 6 and Fig. 1).

Association between PRISM III score and severity

We performed ROC analysis to identify the optimum cutoff value of PRISM III score to differentiate the severity present or absent. It is observed that PRISM score is good to predict severity status, area under the curve of 99%, sensitivity of 95%, and specificity of 98%. The optimum cutoff value of PRISM III is found to be 7 (Table 7 and Fig. 2).

Discussion

PRISM III was found to be an excellent predictor of mortality and severity in our population who were admitted to a tertiary Pediatric Intensive Care Unit. A higher PRISM score is associated with higher mortality. The average value for the PRISM score was 12 for predicting mortality, with 100% sensitivity and 91%

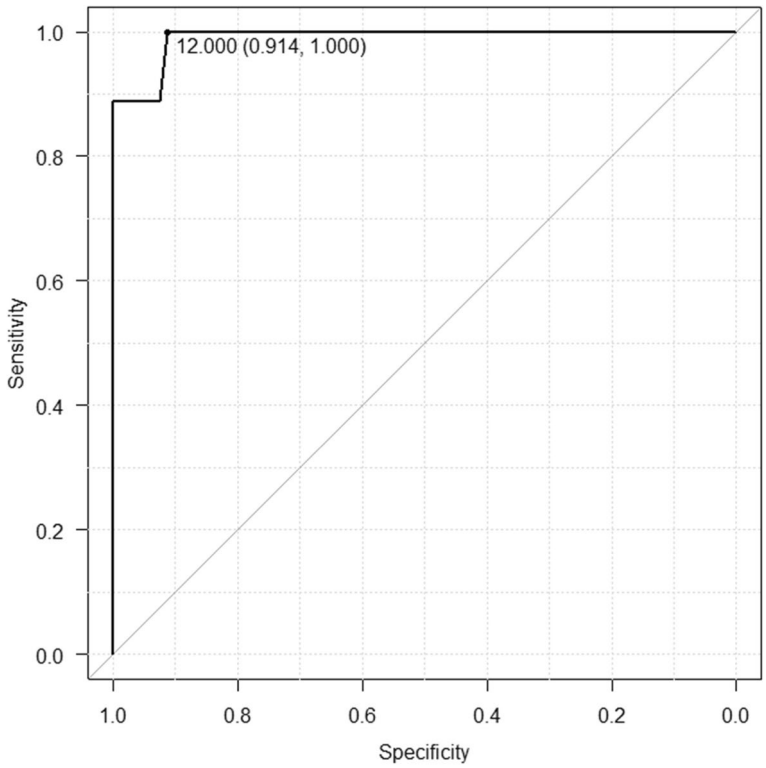

Fig. 1 ROC curve for mortality and PRISM score

Table 7 Association of PRISM III and severity of illness

Severity V/S PRISM score			
NPS	**Severity present**	**Severity absent**	**Total**
NPS < 7	2	68	70
NPS ≥ 7	20	0	20
Total	22	68	**90**

specificity PRISM score of 7 had 100% sensitivity and 95% specificity in predicting severe illness. The area under the curve was 99%.

The findings from this study postulate that the mortality rate predicted by the PRISM III score correlated well with the actual observed mortality rate, hence providing an accurate estimate of the prognosis and outcome of the patients admitted to PICU. Our study showed that an increased PRISM score in admitted patients in the PICU is associated with increased mortality. The same was shown by similar studies by Pollack et al. [8], Balakrishnan et al. [9] and, by El Nawawy [10] from Alexandria, by Choi et al from Hong Kong [11], and Brady et al from the UK [12]. Singhal et al. found the ROC analysis was 72% in their study using the PRISM score. Their conclusion was that the PRISM score is a good predictor of mortality. Joshi S et al. [13] in their study in B.Y.L. Nair Hospital, Mumbai, which was presented in All India Pediatric Conference-2006 (Pedicon'2006), found that PRISM III score was useful in predicting mortality. Clearly, the PRISM score has performed well in our study, and it is comparable to the original developers who found ROC analysis of more than 90%.

In our cohort of patients who were admitted to a tertiary pediatric intensive care unit, PRISM III was revealed to be a highly accurate predictor of death and severity. Higher mortality is correlated with higher PRISM scores. The current investigation shows that PRISM III performs well as a discriminative tool, with an AUC of 0.99, sensitivity of 1, and specificity of 0.91. The average score for mortality was found to be 12. The current study also reveals the effectiveness of PRISM III as a discriminative tool for estimating the severity, with an area under the ROC curve of 0.99, sensitivity of 0.95, and specificity of 1. The average score for forecasting severity was 7. There are few pediatric referral tertiary care centers in a resource-constrained nation like India. The PRISM III score can be helpful in determining which individuals require intensive care in these situations. Poor outcomes are linked to things like mechanical ventilation, the use of inotropic medications, low GCS scores, dilated fixed pupils, low systolic blood pressure, high blood glucose levels, ketoacidosis, shock, and serum creatinine levels.

The current study has been done on a small number of subjects. The validity of a score like the PRISM III will have to be observed by a multicenter trial which

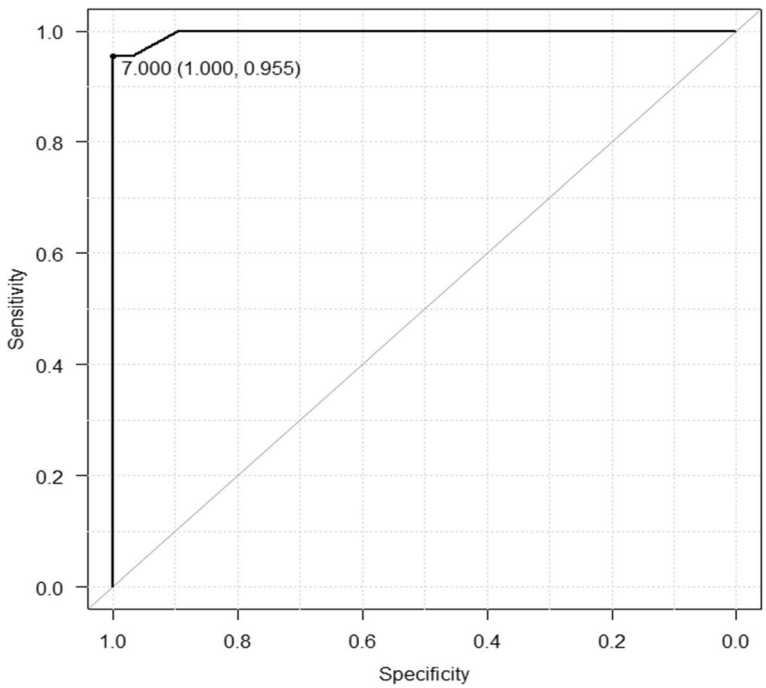

Fig. 2 ROC curve for severity of illness and PRISM score

will allow for a larger number of cases from various locations, hence more representative of an average Indian PICU. The original scoring was developed with larger numbers of patients and at many centers.

Conclusions

There are few pediatric referral tertiary care centers in a resource-constrained nation like India. The PRISM III score can be helpful in determining which individuals require intensive care in such circumstances. Poor outcomes were linked to factors such as inotropic medication use, mechanical ventilation, dilated fixed pupils, low systolic blood pressure, ketoacidosis, high blood glucose levels, and high serum creatinine. A valuable tool for determining the prognosis of pediatric patients admitted to tertiary pediatric critical care units, the PRISM III score demonstrated adequate discriminatory ability.

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Authors' contributions
DTU devised the study and revised the final manuscript, and AM did the data collection and prepared the manuscript. Both authors read and approved the final manuscript.

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Availability of data and materials
All data and materials are available.

Declarations

Ethics approval and consent to participate
Ethics approval by Malankara Orthodox Syrian Church Medical College, Kolenchery, Ernakulam district, Kerala state, e-mail: dean.mosc@gmail.com, Institutional ethics committee no. ECR/728/1nst/K1/2015.

Consent for publication
Not applicable.

Competing interests
The authors declare that they have no competing interests.

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