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Application of Pediatric Risk of Mortality (PRISM) III Score in Predicting Mortality Outcomes

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ABSTRACT

Background: Children admitted in a pediatric intensive care unit have a high risk of mortality. Pediatric risk of mortality III score in first 24 hours of admission has increasingly been used to predict mortality. The objective of this study was to evaluate the validity of Pediatric risk of mortality score in prediction of mortality among the patient admitted in pediatric intensive care unit.

Methods: This prospective observational study was conducted at pediatric intensive care unit of a government pediatric hospital from January to June 2021. Patients between 1 month to 14 years of age and meeting the inclusion criteria were enrolled. Pediatric risk of mortality III score was calculated within 24 hours of admission. Patients were followed up for outcome measure as survivors and non survivors. Chi square test and logistic regression analysis were used to find the association of predictors and the score.

Results: The mean Pediatric risk of mortality III score was lower in survivors than in non-survivors (4.67 $\pm$ 3.8 versus 14.10 $\pm$ 6.07; $p<0.001$). Those requiring inotropic and ventilator support have significantly higher mortality [49.4 versus 0.6 ($p<0.001$) and 81.8 versus 1.5 ($p<0.001$) respectively]. Minimum systolic blood pressure, abnormal pupillary reflex, increased blood urea nitrogen and decreased platelet were the significant ($p<0.001$) risk factors. The area under the Receiver Operating Characteristic curve was 0.916$\pm$0.024 ($p<0.001$) and goodness-of-fit test showed no significant difference between observed and expected mortalities ($p=0.186$).

Conclusions: The Pediatric risk of mortality score constitutes a useful prognostic tool in predicting the mortality.

Key words: Mortality; pediatrics; pediatric intensive care unit; risk score,

INTRODUCTION:

Pediatric intensive care unit (PICU) aims at reducing mortality of critically ill children by identifying patients at risk based on the disease severity during admission in PICU.[1] Various objective scoring systems have been developed to quantify the severity of patients and estimating the probability of death.[2] In 1988, Pollack et al designed Pediatric Risk of Mortality (PRISM) score with 14 variables for prediction of mortality in PICU and was modified in 1996 to PRISM III.[3] The PRISM III score consisting 17 variables uses the worst physiologic & laboratory values of patients within 24 hours of admission.[4] Validity of PRISM III score in developed countries is well established but limited in developing countries. [5]

This study aimed at evaluating the suitability and the accuracy of the PRISM III score in predicting the mortality of patients admitted in PICU of a government pediatric hospital thereby helping in identifying the patients who might benefit from PICU care.

METHODS

This prospective observational study was conducted in PICU of Kanti Children's Hospital (KCH), the only and largest tertiary care Government pediatric hospital in Nepal. The twelve bedded PICU with two extra isolation beds caters to critical care needs of 600 - 700 children per year from 1 month to 14 years of age. This study was conducted over a period of six months from 1st January

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to 30th June 2021 after getting ethical approval from Institutional Review Committee (Ref no:594 /14th Dec 2020) of the hospital. Readmission was taken as separate admission because each admission presented a separate opportunity for an outcome. The causes of illness were grouped as per the primary system involved. Pediatric cases were admitted either from ward or directly to PICU through ER or referred from PICU of other hospital. All subsequent admission was enrolled for study except the following.

patient whose parents did not give consent, death occurring within first 12 h of PICU admission, cases discharged before 24 h of PICU admission, cases discharged on request (DOR), left against medical advice (LAMA) and referred one as their final outcome is not known,

patient with congenital malformation incompatible to life, patients with underlying malignancy and patients whose relevant investigation were not done within 24 hours of PICU admission.

Informed written consent from the parents/guardian was obtained for participation and publishing their data, prior to inclusion in the study. The clinical assessment of vital signs, pupillary reaction and the Glasgow Coma score were noted by the resident doctor or medical officer on duty. Data collected were name, age, gender, inhabitant, diagnosis, duration of stay in PICU, nature of outcome (survival/non-survival), requirement of ventilator and ionotropic support. A complete history, thorough physical examination, and appropriate laboratory investigations were carried out for each patient. All required PRISM III variables were filled in for each patient using the most abnormal values of physiologic and laboratory data within 24 hours of admission to the PICU and PRISM score was calculated. The patients were followed up during the hospital stay and the outcome measures were recorded as survivor and non-survivor at the end of the hospital stay. The total score achieved by each patient was correlated with the outcome.

The scoring method of the original PRISM III was followed as described by Pollack et al. [3] A PRISM III score ranges from 0 to 74 consisting 5 physiologic and 12 laboratory variables categorized into four groups: cardiovascular/ neurologic vital signs (score range: 0–30), Acid based and blood gas (score range: 0–22), biochemical tests (score range: 0–10), and hematological tests (score range: 0–12). The higher the total score, the worst is the prognosis. PRISM III divides cases into four age groups as follows.[3,6,7]

Up to 1 month

>1 to 12 months

>12 to 144 months (12 y) and

> 144 months (> 12 y).

All the data were pooled into Statistical Package for Social Science (SPSS) software version 26.0 (IBM, Armonk, NY) and all the analyses were carried out through it. Categorical variables were expressed as percentage and continuous variables such as age, and length of PICU stay were reported as means with standard deviations. T-test was used to find the association between different components of PRISM score with outcome. Chi-square tests were used to find any association between age, gender, length of stay, source of admission, use of mechanical ventilation, use of ionotropes and outcome as well as to compare the characteristics between survivor and non survivors. Multiple Logistic regression analysis was used for the association between PRISM score, other independent variables and outcome of the treatment. A p-value of < 0.05 was considered statistically significant.

Validation and performance of the scoring system was tested by assessing discrimination and calibration. Discrimination is the ability of a test to calculate a higher mortality probability among non-survivors than survivors across the whole group assessed by calculating area under the ROC curve. [8] An area of 1.00 suggests a perfect model and 0.50 would be expected by chance. An area of 0.70–0.79 is acceptable, 0.80–0.89 is good, and 0.90 or more is excellent. [8-11]

Calibration is an agreement between predicted and observed mortality across different classes of risk and is usually assessed using goodness-of-fit statistic proposed by Hosmer and Lemeshow, where acceptable calibration is defined as $p \geq 0.05$ suggesting no significant difference between the predicted mortality by the score and the observed mortality of the study population. [12] Standard Mortality Ratio (SMR) was calculated by dividing the total actual mortality rate by the cumulative predicted mortality rate of the study population. [1,9]

RESULTS

During the study period, out of 369 total admissions 248 cases were enrolled in the study. Among the enrolled patients 158 were males (63.71%) and 90 were females (36.29%) with male: female ratio of 1.75:1. Mean age of study population was 43.23±49.37 months with mean

age of survivor and non-survivor being 40.17±46.69 and 59.69±59.87 months respectively. The average length of stay (LOS) in PICU was 5.20±4.30 days whereas for survivor and non-survivor was 5.02 ±4.09 and 6.10±5.27 days respectively.

Total mortality in our study was 39 (15.72%) with mortality among male and female was 26 (16.5%) and 13 (14.4%) respectively. Prolonged LOS (>7 days) in PICU increases the mortality (23.8%). Sick children retrieved from other PICU were found to have higher mortality (18.1%) than in-house patients. Those requiring ionotropic and ventilator support have significantly higher mortality in comparison to those not requiring such supports [49.4 vs 0.6 (p=0.001) and (81.8 vs 1.5 (p=0.001) respectively]. The relation of various variable with the outcome is as shown in Table1.

Considering the system involved, renal disorders, endocrine disorders and poisoning had the best prognosis (100% survival but not significant; p= 0.11, 0.24 and 0.28 respectively) followed by respiratory system showing statistically significant better outcome when compared between survivors and non-survivors [(96.34% vs. 3.65%; p<0.001; OR 0.137 (0.41-0.46)]. Other systems also showed favorable outcome but was not statistically significant: Infectious disease (73.33% vs 26.66%, p=0.26), Immunology (72.72% vs 27.27%, p=0.05), Cardiorespiratory (76.66% vs 23.33%, p=0.22), Neurological disorders (85.71% vs. 14.28%, p=0.88) and Hematological disorders (50% vs. 50%, p=0.05).

Rate of mortality increased with increasing PRISM score (Table 2). In our study the mean PRISM score was 6.16±5.44. Comparison of mean PRISM score between survivors and non-survivor was as shown in Table 3.

Table 1. Association between different variables and outcome.

Variables	Total cases (%)	Survivor (%)	Non-survivor (%)	p-value	OR (95%CI)
Gender					
Male	158 (63.71)	132(83.5)	26(16.5)	0.67	1.16(0.56-2.4)
Female	90 (36.29)	77(85.6)	13(14.4)		
Age					
<12 months	106 (42.74)	88(83)	18(17)	0.025	
12-60 months	71(28.62)	67(94.4)	4(5.6)		
61-120 months	48 (19.35)	37(77.1)	11(22.9)		
>120 months	23(9.27)	17(73.9)	6(26.1)		
Length of stay (hours)					
<72	64 (25.8)	52(81.3)	12(18.8)	0.134	
72 to 168	142 (57.3)	125(88)	17(12)		
>168	42 (16.9)	32(76.2)	10(23.8)		
Inotropes (vasoactive drugs)					
Received	77 (31.0)	39(50.6)	38(49.4)	<0.001	165.64 (22.06-1243.48)
Not received	171(69)	170(99.4)	1(0.6)		
Mechanical ventilator					
Required	44 (17.7)	8(18.2)	36(81.8)	<0.001	301.5 (76.34-1190.66)
Not required	204(82.3)	201(98.5)	3(1.5)		
Admitted through					
ER	79 (31.9)	68(86.1)	11(13.9)	0.781	
Ward	97(39.1)	82(84.5)	15(15.5)		
Other PICU	72 (29)	59(81.9)	13(18.1)		
Total	248	209 (84.27)	39 (15.72)		

Table 2. Distribution of patient's outcome according to PRISM III score.								
Prism III score	Total		Survivor		Non survivor		p-value	OR (95% CI)
	No	%	No	%	No	%		
0-5	146	58.9	144	98.6	2	1.4	<0.001	0.25(0.006-0.107)
6-10	56	22.6	47	83.9	9	16.1	<0.001	13.40(2.79-64.22)
11-15	31	12.5	15	48.4	16	51.6	<0.001	76.26(15.97-364.12)
16-20	7	2.82	2	28.6	5	71.4	<0.001	178.75(20.75-1539.58)
>20	8	3.22	1	12.5	7	87.5	<0.001	500.5(40.37-6205.01)

Table 3. Comparison of PRISM III score between survivors and non survivors.			
Patient category	No. of patients	Mean score ± SD	p-value
Survivors	209	4.67 ± 3.8	<0.001
Non-survivors	39	14.10 ± 6.07	
Total	248	6.16±5.44	

Among the characteristics of PRISM score, minimum systolic blood pressure (SBP), poor mental status (low GCS), abnormal pupillary reflex, increased BUN and decreased platelet count has significant (p<0.001) association with mortality. Association of different variables with outcome is as shown below (Table 4).

Table 4. Association of characteristic of PRISM III score with outcome.			
Parameter	Survivors = mean ±SD	Non-survivors= mean ±SD	p-value
Physiological variables			
HR	124.71±24.51	132.03±34.11	0.11
BP	100.41±19.69	84.72±31.50	<0.001
Temperature	37.11±0.62	37.31±1.04	0.098
Mental status(GCS)	14.64±1.33	12.18±3.5	<0.001
Pupillary reflex	0±0.00	0.74±2.66	<0.001
ABG status			
pH	7.42±0.11	7.37±0.13	0.01
PCO2	27.36±9.09	26.81±8.93	0.73
tCO2	18.82±5.46	15.84±5.43	0.002
PO2	118.67±47.66	114.45±66.64	0.636
Biochemistry			
RBS	92.73±34.13	110.36±57.47	0.009
Potassium	4.45±0.93	4.48±1.02	0.845
Creatinine	0.64±0.65	0.88±0.59	0.031
BUN	13.51±12.05	21.08±12.67	<0.001
Hematology			
WBC	10823.06±13252.20	12568.72±11651.4	0.443
Platelet	213214.35±100236.65	138820.51±99300.94	<0.001
PT	19.82±31.21	25.64±23.37	0.270
APTT	47.49±50.62	62.79±57.60	0.091

The result in Table 5 showed that the observed mortality rate was 15.72% and the predicted mortality rate was 15.72% (SMR=1.002). No significant difference was seen between the expected and observed mortality rate (Chi square= 3.36; p=0.186). A p-value of >0.05 is considered good suitability of the test.

Table 5. Goodness of the predictive model by the Hosmer and Lemeshow chi-square test.

Prism III score	Total number	Survivor		Non survivor		SMR	p-Value
		Observed	Predicted	Observed	Predicted		
0-5	146	144	142.11	2	3.89	0.59	
6-10	56	47	48.59	9	7.40	1.21	
11-15	31	15	16.77	16	14.22	1.12	
>16	15	3	1.51	12	13.48	0.89	0.186
Total	248	209	208.97	39	38.99	1.002	

PRISM III scores offered a good discriminative power in our center with 0.916±0.024 (95% CI=0.868-0.963) area under the ROC curve (Figure 1). Taking 10 as cut-off point, the sensitivity and specificity of PRISM III model in our population were 76.4% and 99.8%, respectively.

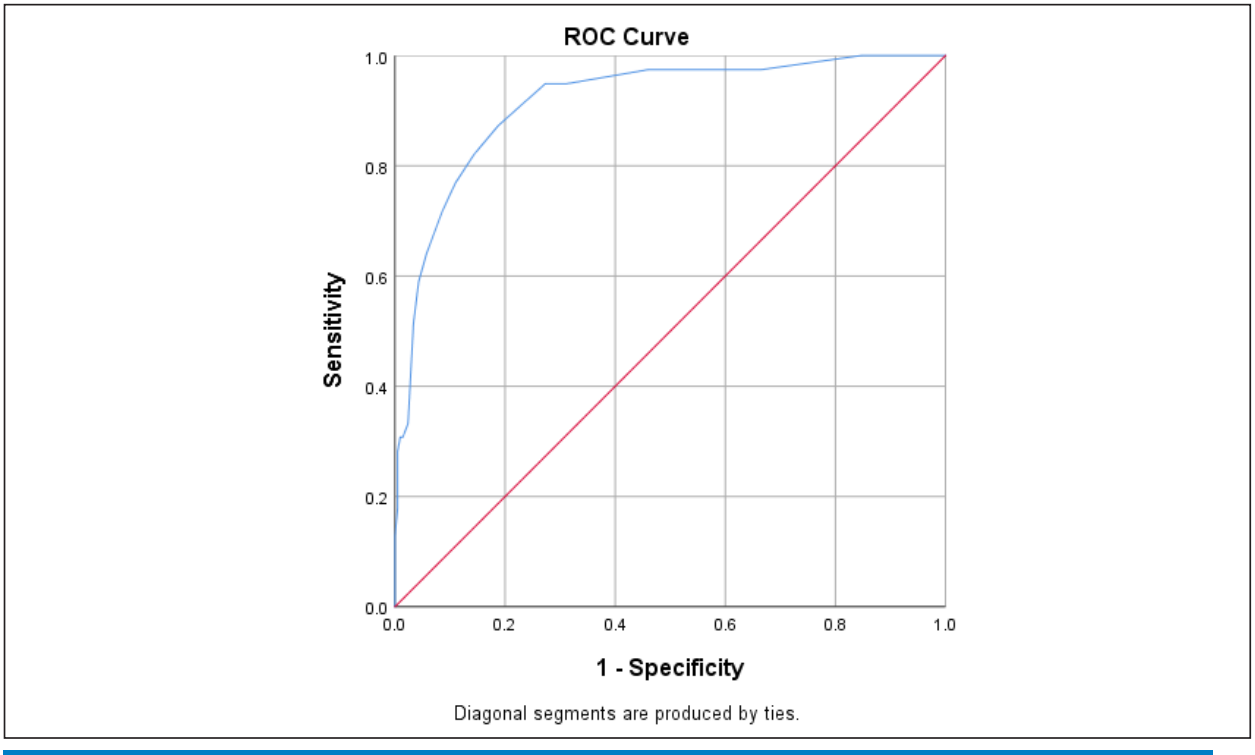

Figure 1.ROC curve: Area under the curve is 0.916±0.024 (p<0.001, 95% CI= 0.868-0.963).

[ROC: receiver operating characteristics; CI: confidence interval]

DISCUSSION

It is important for PICU to identify groups at risk of death and to ensure the adequacy of treatment by categorizing the disease severity at admission and assessing its prognosis. [1] Because prediction of mortality risk by pediatricians is highly subjective, various severity scoring systems have been developed to objectively quantify the severity of patients and estimating the probability of death according to their clinical state at the time of admission. [2] Pediatric Risk of Mortality (PRISM) and the Pediatric Index of Mortality (PIM) are the principal score developed for the prediction of mortality in pediatric population with their most recent versions being PRISM III and PIM-II. [1] The purpose of this study was to use a critical illness scoring system like PRISM III to assess the mortality risk and its validity in predicting the

outcome of patients admitted to PICU of a tertiary care hospital in resource-limited settings.

In our study the mean PRISM III score was 6.16±5.44 which was significantly lower in survivors than in non-survivor (4.67 ± 3.8 vs. 14.10 ± 6.07; p<0.001) suggesting higher PRISM III scores on admission correlated significantly with a higher risk of mortality which corresponds to several earlier studies carried out in Srilanka, Nepal and India. [6, 13, 14]

Using logistic regression, we found that minimum SBP, pupillary reflex, increased BUN and decreased platelet count has statistically significant (p<0.001) association with mortality. Acidic pH (p=0.01), decreasing tCO2 (p=0.002), increased RBS (p=0.009) and creatinine (p=0.03) were also associated with poor outcome. We further observed that the use of mechanical ventilation and vasoactive drugs were significant risk factors (p<0.001) for mortality corroborating the findings of other authors who showed a higher mortality rate in patients requiring these lifesaving supports. [2, 6, 11, 13, 15]

A study by Mirza *et al* in Karachi found that minimum SBP, abnormal pupillary reflex, higher temperature, and low GCS in addition to use of mechanical ventilation (p=0.009) & ionotropic drugs (p=0.005) were significantly associated with mortality.[2] Another study by Pollack *et al* also reported that minimum SBP, abnormal pupillary reflexes, and coma were significantly associated with mortality.[3] Similar study by Kaur *et al* also reported that use of mechanical ventilation, low GCS, deranged coagulation profile, tachycardia, and increase in pH significantly affected the mortality.[11] Several other studies done earlier also revealed similar findings.[1, 12, 13] These differences in the reporting of association of different variables with mortality could be due to the different system involvement at different centers at the time of presentation.[11]

The finding from our study revealed that mortality rate predicted by PRISM III score correlated well with the actual observed mortality rate thus providing an accurate estimate of prognosis and outcome of patients admitted in PICU. The observed mortality in this study was 15.72%, comparable to similar study done in Thailand (13.9%) and Maharastra, India (14.8%).[4, 7] However, it was much lower than that in Karachi (37.35%)[2] and higher in comparison to Belgaun, India (9.3%)[1] and Nepalgunj Medical College, Nepal (9.2%).[13] This difference could be due to difference in sample size, age distribution of patients and their disease pattern, quality of care and also the duration of study. Our study was done for only six months whereas others were done over 12 to 18 months. The result showed that the expected mortality rate was 15.72% and the observed mortality rate in our study was 15.72%. No significant difference was seen between the expected and observed mortality rate (p=0.186) and SMR being 1.002.

In this study, PRISM III scores offered a good discriminative power in our center with area under the curve (AUC) being 0.916±0.024 (p<0.001; 95% CI: 0.868-0.963). The AUC is a measure of the overall accuracy of the model as well as its ability to predict mortality. The closer the AUC is to 1.0, the more accurate the model is.[7, 9, 12] Our results are in consonance with similar other studies with discriminative power of >0.9 in the AUC [2 8, 11]while discriminatory power of <0.9 was reported by few other studies. [13, 16-18] Taking 10 as cut-off point, the sensitivity and specificity of PRISM III model in our population were 76.4% and 99.8%, respectively. Calibration ability of PRISM III, tested by goodness-of-fit test showed no significant difference between the observed and expected mortalities (p=0.186). Since the expected and observed mortalities are comparable, the model has a significantly good calibration for our PICU.

Majority of our cases were male and infant as in other studies.[2, 16] In this study though age is significantly associated with mortality (p=0.025) as shown by Verma et al [7], gender and LOS in PICU did not show any significant influence on the mortality outcome (p=0.67 and p=0.134 respectively) supporting the finding of similar studies from within and outside the country.[2, 13, 18] In our study older aged children had higher mortality in contrast to other finding probably because older children are brought to hospital late as compared to younger infants.

Majority of the patients were admitted from the ward without any significant influence on the outcome as observed by similar studies conducted in India. [1] We found that majority of PICU admission were due to respiratory diseases and had significantly better outcome while comparing survivor and non-survivor (96.34% vs 3.65%, p<0.001) corresponding to similar finding in Ezypt [19] and contrary to the finding of an earlier study in Nepal [13] where disease of respiratory system was most common cause of death. This could be due to late presentation and delay in admission to the PICU in periphery where there are limited facility of PICU. Our study didn't show any significant relationship with the risk of death and underlying disease condition as has been found in neighboring countries.[6] In contrast, study in Ezypt and India showed significant correlation between the cause of illness and outcome which could be attributed to the

more serious clinical condition of patients at the time of presentation to the hospital. [19, 20]

Application of these scoring systems helps in assessing PICU performance and comparing the quality of care of different PICUs and within the same PICU over time. [1] Being a single centered study covering a small sample size compared with the original validation studies and over a short period of time the result of this study may not be representative of the rest of the country. A larger multi-centric study with large number of sample may provide more conclusive results with greater generalization of the validity of this model in Nepalese PICUs.

CONCLUSIONS

Rate of mortality increased with increasing PRISM score. The PRISM III scores exhibited good capacity to discriminate between survivors and non survivors and can be used as a tool with comparable performance for prognostic evaluation of pediatric patients admitted in a PICU setup. Regular use of scoring systems in PICU also helps in improvement of the quality of care within the limited resources available.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

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