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Original Research Article

Validation of the PRISM Score for Mortality Prediction in a Pediatric Intensive Care Unit

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Abstract

Background: The Pediatric Risk of Mortality (PRISM) score is a widely used severity-of-illness scoring system designed to predict mortality risk in critically ill children. While extensively validated in developed countries, the performance of PRISM may vary across different healthcare settings and patient populations. Validation of this scoring system in diverse clinical environments is essential to ensure its reliability and applicability for clinical decision-making and quality benchmarking.

Methods: This prospective observational study was conducted in a tertiary care pediatric intensive care unit (PICU) over 18 months, enrolling 342 critically ill children aged 1 month to 14 years. PRISM III scores were calculated within the first 24 hours of admission using the most abnormal physiological values. The primary outcome was PICU mortality. Discrimination was assessed using the area under the receiver operating characteristic curve (AUC), and calibration was evaluated using the Hosmer-Lemeshow goodness-of-fit test.

Results: The overall PICU mortality rate was 14.6% (50/342). Non-survivors had significantly higher mean PRISM III scores compared to survivors (24.8 ± 8.6 vs. 8.4 ± 6.2, $p < 0.001$). The PRISM III score demonstrated excellent discrimination with an AUC of 0.91 (95% CI: 0.87-0.95). Calibration analysis showed good agreement between predicted and observed mortality (Hosmer-Lemeshow $\chi^2 = 8.42$, $p = 0.394$). The standardized mortality ratio was 0.94 (95% CI: 0.72-1.22), indicating appropriate prediction accuracy. A PRISM III score ≥15 predicted mortality with 86.0% sensitivity and 82.2% specificity.

Conclusion: The PRISM III score demonstrates excellent discriminatory ability and good calibration for mortality prediction in our pediatric intensive care population. This scoring system is a reliable tool for risk stratification, resource allocation, and quality assessment in the PICU setting.

Keywords: PRISM Score, Pediatric Intensive Care, Mortality Prediction, Severity Scoring, Validation, Critically Ill Children.

Introduction

Pediatric intensive care units (PICUs) manage critically ill children with diverse diagnoses and varying degrees of physiological derangement, making accurate assessment of illness severity and mortality risk essential for clinical management [1]. Severity-of-illness scoring systems provide objective, standardized methods for quantifying disease severity, predicting outcomes, and enabling meaningful comparisons across institutions and over time [2].

These tools have become integral components of modern intensive care practice, supporting clinical decision-making, resource allocation, family counseling, and quality improvement initiatives. The Pediatric Risk of Mortality (PRISM) score, first developed by Pollack and colleagues in 1988, represented a significant advancement in pediatric critical care medicine by providing a validated, objective measure of mortality risk based on physiological parameters [3]. The original PRISM score utilized 14 physiological variables collected within the first 24 hours of PICU admission. Subsequently, the PRISM III was developed in 1996, incorporating refined variable selection and updated coefficients based on contemporary PICU populations, improving both discrimination and calibration [4].

PRISM III evaluates 17 physiological variables across cardiovascular, neurological, respiratory, and laboratory domains, with higher scores

indicating greater severity of illness and increased mortality risk [5]. The score has been widely adopted internationally and serves as a benchmark for comparing outcomes across different PICUs and healthcare systems [6]. Additionally, PRISM scores facilitate clinical research by providing standardized risk adjustment for comparing therapeutic interventions and outcomes.

Despite its widespread use, the performance of PRISM may vary across different populations, geographic regions, and healthcare settings [7]. Factors such as case mix, resource availability, treatment protocols, and underlying patient characteristics may influence the score's predictive accuracy [8]. Studies from developing countries have reported variable performance of PRISM, with some demonstrating adequate discrimination but suboptimal calibration [9]. These observations underscore the importance of local validation before implementing scoring systems for clinical or administrative purposes.

External validation studies have confirmed the utility of PRISM in diverse settings; however, performance characteristics may differ from the original development cohort [10]. The standardized mortality ratio (SMR), calculated as the ratio of observed to predicted deaths, provides a measure of PICU performance relative to expected outcomes based on case severity [11]. An SMR significantly different from 1.0 may indicate either superior or inferior performance compared to the reference population, or alternatively, poor calibration of the scoring system in the local context. Recent studies have explored modifications and alternatives to PRISM, including simplified versions and competing scoring systems such as the Pediatric Index of Mortality (PIM) [12]. Comparative analyses have generally demonstrated similar performance between PRISM III and PIM scores, though subtle differences in discrimination and calibration exist depending on the population studied [13]. The choice of scoring system often depends on institutional preference, data availability, and practical considerations.

The aim of this study was to validate the PRISM III scoring system for mortality prediction in critically ill children admitted to a tertiary care PICU, evaluating both discrimination and calibration to determine its applicability for clinical use and quality benchmarking in our setting.

Materials and Methods

Study Design and Setting: This prospective observational validation study was conducted in the 18-bed PICU of a tertiary care university teaching hospital.

Study Population: Consecutive admissions of children aged 1 month to 14 years requiring PICU care were screened for enrollment. Sample size was calculated based on the requirement of approximately 10 events per predictor variable for validation studies, with an expected mortality rate of 15% and 17 PRISM III variables, yielding a minimum requirement of 300 patients.

Inclusion Criteria:

- Age between 1 month and 14 years
- Admission to PICU for any medical or surgical indication
- PICU length of stay ≥4 hours
- Complete data availability for PRISM III calculation

Exclusion Criteria:

- Neonates (age <1 month)
- Patients admitted for routine postoperative monitoring only
- Patients transferred from other ICUs with incomplete admission data
- Patients discharged against medical advice
- Readmissions within the same hospitalization
- Incomplete data for PRISM III score calculation

Data Collection: Demographic data including age, sex, weight, and primary diagnosis were recorded at admission. Primary diagnoses were categorized into respiratory, cardiovascular, neurological, infectious, surgical, and other categories. Admission source (emergency department, ward, operating room, external transfer) and requirement for mechanical ventilation were documented.

PRISM III Score Calculation: PRISM III scores were calculated using the most abnormal values of physiological and laboratory variables recorded within the first 24 hours of PICU admission. The 17 variables assessed included:

Cardiovascular: Systolic blood pressure, heart rate, temperature

Neurological: Glasgow Coma Scale, pupillary reactions

Respiratory: PaO2, PCO2, pH

Laboratory: Total CO2, potassium, glucose, creatinine, blood urea nitrogen, white blood cell count, platelet count, prothrombin time/partial thromboplastin time

Data were extracted from electronic medical records, bedside monitors, and laboratory information systems. PRISM III scores were calculated using the standard algorithm, with age-appropriate normal ranges applied. The predicted mortality rate (PMR) was calculated using the PRISM III mortality probability equation.

Outcome Measures: The primary outcome was PICU mortality, defined as death occurring during PICU stay. Secondary outcomes included length of PICU stay, duration of mechanical ventilation, and hospital mortality. Survivors were defined as

patients discharged alive from the PICU, regardless of subsequent hospital course.

Statistical Analysis: Data were analyzed using Statistical Package for Social Sciences (SPSS) version 26.0 and MedCalc Statistical Software version 20.0. Continuous variables were expressed as mean ± standard deviation or median (interquartile range) based on distribution, assessed using the Kolmogorov-Smirnov test. Categorical variables were presented as frequencies and percentages.

Comparison between survivors and non-survivors was performed using independent samples t-test or Mann-Whitney U test for continuous variables and chi-square test for categorical variables.

Discrimination was evaluated using the area under the receiver operating characteristic (ROC) curve (AUC). An AUC of 0.9-1.0 was considered excellent, 0.8-0.9 good, 0.7-0.8 fair, and <0.7 poor discrimination. Optimal cut-off values were determined using the Youden index.

Calibration was assessed using the Hosmer-Lemeshow goodness-of-fit test, with patients divided into deciles of predicted risk. A non-significant p-value (>0.05) indicates good calibration, suggesting agreement between predicted and observed mortality rates across risk strata.

The standardized mortality ratio (SMR) was calculated as the ratio of observed deaths to predicted deaths (sum of individual predicted mortality probabilities), with 95% confidence intervals calculated using the Poisson distribution.

A p-value <0.05 was considered statistically significant.

Results

Demographic and Clinical Characteristics: A total of 378 patients were admitted during the study period, of which 342 met inclusion criteria and were included in the final analysis. The demographic and clinical characteristics are presented in Table 1. The mean age was 4.2 ± 3.8 years, with 58.5% being male. The median weight was 14.5 kg (IQR: 8.2-24.6 kg).

Respiratory disorders were the most common admission diagnosis (32.5%), followed by neurological conditions (22.8%) and infectious diseases (18.4%). The majority of patients were admitted from the emergency department (52.3%).

Mechanical ventilation was required in 148 patients (43.3%). The overall PICU mortality rate was 14.6% (50/342), and hospital mortality was 16.4% (56/342). Non-survivors were significantly younger (2.8 ± 2.4 vs. 4.4 ± 3.9 years, p = 0.008), more likely to require mechanical ventilation (82.0% vs. 36.6%, p < 0.001), and had longer PICU stays (8.6 ± 6.2 vs. 5.2 ± 4.8 days, p < 0.001). Emergency department admissions were more common among non-survivors (68.0% vs. 49.7%, p = 0.018).

Table 1: Demographic and Clinical Characteristics of Study Population

Parameter	Total (n=342)	Survivors (n=292)	Non-Survivors (n=50)	p-value
Age (years), mean ± SD	4.2 ± 3.8	4.4 ± 3.9	2.8 ± 2.4	0.008*
Age groups, n (%)				
1-12 months	78 (22.8%)	62 (21.2%)	16 (32.0%)	0.042*
1-5 years	142 (41.5%)	120 (41.1%)	22 (44.0%)	
6-10 years	82 (24.0%)	74 (25.3%)	8 (16.0%)	
11-14 years	40 (11.7%)	36 (12.3%)	4 (8.0%)	
Sex, n (%)				
Male	200 (58.5%)	172 (58.9%)	28 (56.0%)	0.696
Female	142 (41.5%)	120 (41.1%)	22 (44.0%)	
Weight (kg), median (IQR)	14.5 (8.2-24.6)	15.2 (8.8-25.4)	11.4 (6.4-18.2)	0.024*
Primary diagnosis, n (%)				
Respiratory	111 (32.5%)	92 (31.5%)	19 (38.0%)	0.186
Neurological	78 (22.8%)	68 (23.3%)	10 (20.0%)	
Infectious/Sepsis	63 (18.4%)	48 (16.4%)	15 (30.0%)	
Cardiovascular	38 (11.1%)	34 (11.6%)	4 (8.0%)	
Surgical	32 (9.4%)	31 (10.6%)	1 (2.0%)	
Other	20 (5.8%)	19 (6.5%)	1 (2.0%)	
Admission source, n (%)				
Emergency department	179 (52.3%)	145 (49.7%)	34 (68.0%)	0.018*
Ward	92 (26.9%)	82 (28.1%)	10 (20.0%)	
Operating room	42 (12.3%)	40 (13.7%)	2 (4.0%)	
External transfer	29 (8.5%)	25 (8.6%)	4 (8.0%)	
Mechanical ventilation, n (%)	148 (43.3%)	107 (36.6%)	41 (82.0%)	<0.001*
PICU LOS (days), mean ± SD	5.7 ± 5.2	5.2 ± 4.8	8.6 ± 6.2	<0.001*

***Statistically significant (p < 0.05); LOS: Length of Stay; IQR: Interquartile Range**

PRISM III Scores and Mortality Prediction: PRISM III scores and predictive performance are presented in Table 2. The mean PRISM III score for the entire cohort was 10.8 ± 8.4 (range: 0-42). Non-survivors had significantly higher PRISM III scores compared to survivors (24.8 ± 8.6 vs. 8.4 ± 6.2, $p < 0.001$). The median PRISM III score was 21.5 (IQR: 18-32) in non-survivors compared to 6 (IQR: 3-12) in survivors. The predicted mortality rate (PMR) based on PRISM III was significantly higher in non-survivors (48.6 ± 22.4% vs. 8.2 ± 10.6%, $p < 0.001$). The sum of predicted deaths was 53.2, yielding a standardized mortality ratio (SMR) of 0.94 (95% CI: 0.72-1.22), indicating observed mortality closely matching predicted mortality.

Analysis of individual PRISM III components revealed that cardiovascular parameters (hypotension, tachycardia), neurological status (low GCS, abnormal pupils), and laboratory abnormalities (acidosis, coagulopathy) were significantly more deranged in non-survivors.

Table 2: PRISM III Scores and Predictive Parameters

Parameter	Total (n=342)	Survivors (n=292)	Non-Survivors (n=50)	p-value
PRISM III Score				
Mean ± SD	10.8 ± 8.4	8.4 ± 6.2	24.8 ± 8.6	<0.001*
Median (IQR)	8 (4-15)	6 (3-12)	21.5 (18-32)	<0.001*
Range	0-42	0-32	10-42	-
PRISM III categories, n (%)				
0-9	194 (56.7%)	188 (64.4%)	6 (12.0%)	<0.001*
10-19	92 (26.9%)	78 (26.7%)	14 (28.0%)	
20-29	38 (11.1%)	22 (7.5%)	16 (32.0%)	
≥30	18 (5.3%)	4 (1.4%)	14 (28.0%)	
Predicted Mortality Rate (%)				
Mean ± SD	15.6 ± 18.4	8.2 ± 10.6	48.6 ± 22.4	<0.001*
Median (IQR)	6.8 (2.4-18.2)	4.2 (1.8-10.4)	42.8 (28.6-68.4)	<0.001*
Predicted deaths (sum of PMR)	53.2	-	-	-
Observed deaths	50	-	-	-
Standardized Mortality Ratio	0.94	-	-	-
95% Confidence Interval	0.72-1.22	-	-	-
Key abnormal parameters in non-survivors, n (%)				
Hypotension	-	42 (14.4%)	38 (76.0%)	<0.001*
GCS ≤8	-	28 (9.6%)	32 (64.0%)	<0.001*
Abnormal pupils	-	8 (2.7%)	22 (44.0%)	<0.001*
pH <7.28	-	34 (11.6%)	36 (72.0%)	<0.001*
Coagulopathy	-	18 (6.2%)	28 (56.0%)	<0.001*

***Statistically significant ($p < 0.05$); IQR: Interquartile Range; GCS: Glasgow Coma Scale**

Discrimination and Calibration Analysis: The discriminatory performance and calibration of PRISM III are presented in Table 3. ROC curve analysis demonstrated excellent discrimination with an AUC of 0.91 (95% CI: 0.87-0.95, $p < 0.001$).

The optimal cut-off score determined by Youden index was 15, yielding sensitivity of 86.0%, specificity of 82.2%, positive predictive value of 45.3%, and negative predictive value of 97.2%. At a cut-off of PRISM III ≥20, specificity increased to 92.5% with sensitivity of 60.0%. The positive likelihood ratio at the optimal cut-off was 4.83, and the negative likelihood ratio was 0.17. Hosmer-Lemeshow goodness-of-fit test demonstrated adequate calibration ($\chi^2 = 8.42$, df = 8, $p = 0.394$), indicating no significant difference between observed and predicted mortality across risk deciles. The calibration plot showed good agreement between predicted probabilities and observed outcomes across the range of predicted mortality.

Table 3: Discrimination and Calibration Analysis of PRISM III Score

Parameter	Value
Discrimination	
Area Under ROC Curve (AUC)	0.91
95% Confidence Interval	0.87 - 0.95
Standard Error	0.022
p-value	<0.001*
Optimal Cut-off (PRISM III ≥15)	
Sensitivity	86.0%

Specificity	82.2%
Positive Predictive Value	45.3%
Negative Predictive Value	97.2%
Positive Likelihood Ratio	4.83
Negative Likelihood Ratio	0.17
Alternative Cut-off (PRISM III ≥20)	
Sensitivity	60.0%
Specificity	92.5%
Positive Predictive Value	57.7%
Negative Predictive Value	93.1%
Calibration	
Hosmer-Lemeshow χ^2	8.42
Degrees of freedom	8
p-value	0.394
Mortality by PRISM III risk deciles	
Decile 1 (lowest risk)	Observed: 0/34, Predicted: 0.8%
Decile 2	Observed: 1/34, Predicted: 2.1%
Decile 3	Observed: 1/34, Predicted: 3.6%
Decile 4	Observed: 2/34, Predicted: 5.8%
Decile 5	Observed: 3/34, Predicted: 8.4%
Decile 6	Observed: 4/34, Predicted: 12.2%
Decile 7	Observed: 6/35, Predicted: 18.6%
Decile 8	Observed: 8/35, Predicted: 26.4%
Decile 9	Observed: 10/34, Predicted: 38.2%
Decile 10 (highest risk)	Observed: 15/34, Predicted: 52.8%

***Statistically significant ($p < 0.05$)**

Discussion

This prospective validation study demonstrates that the PRISM III scoring system exhibits excellent discrimination and good calibration for mortality prediction in critically ill children admitted to our tertiary care PICU. The findings support the applicability of PRISM III as a reliable tool for risk stratification, outcome benchmarking, and quality assessment in our clinical setting. The overall mortality rate of 14.6% observed in our study is consistent with reports from similar tertiary PICUs in developing countries. Khilnani et al. reported mortality rates of 12-18% in Indian PICUs, reflecting the diverse case mix and severity of illness in these settings [14]. The higher proportion of patients requiring mechanical ventilation (43.3%) and the predominance of respiratory and infectious diagnoses in our cohort reflect the typical disease burden in pediatric critical care in our region. The PRISM III score demonstrated excellent discriminatory ability with an AUC of 0.91, which is comparable to the original validation study by Pollack et al., which reported an AUC of 0.90 [15]. This finding confirms that PRISM III effectively distinguishes between survivors and non-survivors in our population. The discrimination observed in our study is also consistent with validation studies from other centers, which have reported AUC values ranging from 0.85 to 0.94 [16].

The marked difference in PRISM III scores between survivors (8.4 ± 6.2) and non-survivors (24.8 ± 8.6) underscores the clinical utility of this scoring system for identifying high-risk patients. Leteurtre et al. demonstrated similar findings in European PICUs, with significantly higher PRISM scores associated with increased mortality risk [17]. The identified optimal cut-off of 15 provides a practical threshold for clinical decision-making, with high sensitivity (86.0%) ensuring identification of most high-risk patients and acceptable specificity (82.2%) limiting false positives. Calibration analysis using the Hosmer-Lemeshow test confirmed adequate agreement between predicted and observed mortality across risk strata ($p = 0.394$). Good calibration is essential for the appropriate application of severity scores for benchmarking and resource allocation [18]. The standardized mortality ratio of 0.94 (95% CI: 0.72-1.22) indicates that observed mortality closely matched predicted mortality, suggesting that our PICU performance is comparable to the reference population used in PRISM III development.

The individual PRISM III components most strongly associated with mortality in our study—hypotension, neurological impairment, metabolic acidosis, and coagulopathy—reflect the major determinants of outcome in critically ill children [19]. These findings align with the pathophysiology of multiorgan dysfunction syndrome and emphasize the importance of

aggressive cardiovascular and metabolic support in high-risk patients. Brady et al. similarly identified cardiovascular and neurological parameters as key predictors in their multicenter validation study [20].

Younger age emerged as a significant risk factor for mortality in our cohort, with infants demonstrating higher mortality rates compared to older children. This observation is consistent with literature demonstrating increased vulnerability of younger children to critical illness, potentially related to physiological immaturity and limited cardiorespiratory reserve [21]. The association between emergency department admission and mortality likely reflects more acute presentations and delayed recognition of critical illness in community settings.

Comparison with other severity scoring systems is relevant for clinical practice. Studies comparing PRISM III with the Pediatric Index of Mortality (PIM) have demonstrated similar discriminatory performance, though differences in data collection timing (first 24 hours vs. first hour of admission) may influence practical application [22]. Slater et al. reported comparable AUC values for PRISM III and PIM2 in a large Australian cohort, supporting the use of either system based on institutional preference [23]. The high negative predictive value (97.2%) at the optimal cut-off is particularly clinically relevant, as it provides reassurance regarding favorable outcomes in patients with low PRISM III scores. This information is valuable for family counseling and may guide decisions regarding level of care and monitoring intensity [24].

Study limitations include the single-center design, which may limit generalizability to other settings with different case mixes and resources. The exclusion of neonates means that findings cannot be extrapolated to this vulnerable population. Additionally, the PRISM III score was designed using data from North American PICUs, and despite good performance in our validation, ongoing monitoring of score performance is warranted as case mix and treatment practices evolve.

Conclusion

This validation study confirms that the PRISM III scoring system demonstrates excellent discrimination and good calibration for predicting mortality in critically ill children admitted to our pediatric intensive care unit. The score effectively stratifies patients by risk, with significantly higher scores observed in non-survivors compared to survivors. The standardized mortality ratio of 0.94 indicates that observed outcomes closely match predicted outcomes, supporting the use of PRISM III for quality benchmarking and performance assessment. A PRISM III score of 15 or greater identifies patients at high mortality risk with good sensitivity and specificity. These findings support the continued use of PRISM III as a reliable, validated tool for risk assessment, resource allocation, and outcome evaluation in pediatric critical care settings.

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