Eduvest – Journal of Universal Studies
Volume 5 Number 4, April, 2025
p- ISSN 2775-3735- e-ISSN 2775-3727

VALIDATION OF PIM 3, PRISM III, AND PELOD 2 SCORES AS PREDICTORS OF MORTALITY IN ACUTE RESPIRATORY DISTRESS SYNDROME IN PEDIATRIC INTENSIVE CARE UNIT

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ABSTRACT

Acute Respiratory Distress Syndrome (ARDS) is a life-threatening condition in pediatric patients characterized by alveolar fluid accumulation that disrupts gas exchange. Various scoring systems—Pediatric Index of Mortality 3 (PIM 3), Pediatric Risk of Mortality III (PRISM III), and Pediatric Logistic Organ Dysfunction 2 (PELOD 2)—are utilized to estimate mortality, disease severity, and organ dysfunction. However, their validation specifically in pediatric ARDS remains limited. This prospective cohort study aims to evaluate the predictive validity of PIM 3, PRISM III, and PELOD 2 in children aged 1 month to 18 years diagnosed with ARDS and admitted to the Pediatric Intensive Care Unit (PICU). A total of 60 patients were enrolled, with 16 observed for a full 28-day period and 44 reaching clinical outcomes earlier (19 deaths, 25 survivals). Each scoring system was assessed using Receiver Operating Characteristic (ROC) analysis to determine optimal cut-off values for mortality prediction. The PIM 3 score with a cut-off of ≥6.8 yielded a sensitivity of 90.0% and specificity of 95.0%. PRISM III with a cut-off of ≥26 showed 85.0% sensitivity and 100% specificity, while PELOD 2 with a cut-off of ≥9 demonstrated similar performance (85.0% sensitivity, 100% specificity). Among the three, PIM 3 exhibited superior sensitivity for mortality prediction. These findings support the clinical utility of PIM 3 as a more responsive tool for early risk stratification in pediatric ARDS, aiding in timely and targeted interventions.

KEYWORDS Validation PIM 3 Score, PRISM III Score, PELOD 2 Score, Predictors of Mortality

How to cite: Sihombing, R. M., Suparyatha, I. B. G & Putra, I. G. N. S. (2025). Validation of PIM 3, Prism III, and Pelod 2 Scores As Predictors of Mortality in Acute Respiratory Distress Syndrome in Pediatric Intensive Care Unit. Journal Eduvest. *5*(4): 4091-4101.
E-ISSN: 2775-3727
Published by: https://greenpublisher.id/

Article Info:
Submitted: 13-09-2024 Final Revised: 23-04-2025 Accepted: 01-05-2025 Published: 01-05-2025

INTRODUCTION

Acute respiratory distress syndrome (ARDS) is an emergency condition that occurs due to the accumulation of fluid in the alveoli, which disrupts gas exchange so that the distribution of oxygen to the tissues is reduced. It is estimated that acute respiratory distress syndrome accounts for 1-4% of all patients admitted to pediatric intensive care units, with approximately 8-10% requiring mechanical ventilation and an estimated mortality of 20-75% (Erickson et al., 2007).

The pediatric intensive care unit (UPIA) is a place of care specifically designed in a hospital to care for children who are seriously ill. The availability of UPIA facilities and infrastructure varies greatly between developed, developing, and underdeveloped countries. The availability of this unit in various places is much less than the need for a pediatric intensive care unit. The main goal of patient care at UPIA is to save the lives of patients who are seriously or critically ill, but have a hope of recovery. (Tressa Bayu, Martuti, & Salimo, 2018)

Several scoring systems were created to provide an overview of mortality, outcome prediction, disease severity prediction, and organ function failure. These scoring systems also help in clinical decision-making, standardizing research, and comparing patient care between pediatric intensive care units. (Hamshary, Sherbini, Elgebaly, & Amin, 2017)

According to research conducted in Dubai by Malthotra et al. 2019, the Pediatric Index of Mortality 3 (PIM 3) score system had a reasonable accuracy rate in predicting mortality rates in patients in intensive care units at 87%. Meanwhile, research conducted in Surakarta by Tress et al in (2018) explained that the Pediatric Risk of Mortality III (PRISM III) score system was superior in predicting mortality in non-surgical critically ill pediatric patients when compared with the Pediatric Logistic Organ Dysfunction 2 score. (Malhotra, Nour, El Halik, & Zidan, 2019)

An article written by Bakhtiar et al. in 2018 said that in determining the prognosis of an acute respiratory distress syndrome, the hypoxemia score is not only assessed; another, more accurate score is needed because the cause of death of patients with acute respiratory distress syndrome is not only refractory (recurrent) hypoxemia, even though hypoxemia is the main target in resuscitation measures. (Bakhtiar & Maranatha, 2018)

Until now, there is no evaluation data regarding PIM 3, PRISM III, and PELOD 2 scores for acute respiratory distress syndrome. This study aimed to assess the validity of the PIM 3, PRISM III, and PELOD 2 scores in children with acute respiratory distress syndrome in the pediatric intensive care unit.

Previous studies have evaluated the performance of various pediatric scoring systems in predicting mortality in intensive care settings. Malhotra et al. (2019) found that the PIM 3 score had a strong predictive value with 87% accuracy in pediatric intensive care units. Similarly, in Surakarta, Tress et al. (2018) concluded

that PRISM III showed better predictive ability than PELOD 2 in non-surgical critically ill pediatric patients. Meanwhile, Bakhtiar et al. (2018) emphasized the need for comprehensive scoring beyond hypoxemia parameters in patients with acute respiratory distress syndrome (ARDS), as mortality is often not solely due to refractory hypoxemia. Despite these findings, no prior research has compared the validity of PIM 3, PRISM III, and PELOD 2 scores specifically in children diagnosed with ARDS. This study fills the gap by evaluating and comparing these scoring systems in pediatric ARDS cases, thereby providing novel insight into their predictive reliability in a disease-specific context.

This study aims to evaluate the validity of PIM 3, PRISM III, and PELOD 2 scores as predictors of mortality in pediatric patients with acute respiratory distress syndrome admitted to the Pediatric Intensive Care Unit. The theoretical benefit of this study is to contribute to the refinement of mortality prediction tools in pediatric critical care, while its practical benefit is to assist clinicians in identifying high-risk patients more accurately, improving triage, and optimizing treatment strategies in PICUs.

RESEARCH METHOD

This research is an observational analytical study using a diagnostic test design, conducted in the Pediatric Intensive Care Unit (PICU) from September 2022 to April 2023. The study population included all pediatric patients aged 1 month to 18 years diagnosed with acute respiratory distress syndrome (ARDS). Prior to enrollment, informed consent was obtained from all parents or guardians after receiving a thorough explanation regarding the study.

Inclusion criteria covered patients within the specified age range diagnosed with ARDS based on standard clinical and radiological parameters. Exclusion criteria included patients with congenital abnormalities, those who died within the first hour of PICU admission, and those discharged for non-medical or administrative reasons within the first 24 hours.

The minimum required sample size was calculated using a sensitivity analysis formula assuming an expected sensitivity of 85%, a confidence level of 95%, and a precision of ±10%. This resulted in a minimum required sample size of 60 patients to ensure statistical power and reliability of the results. Each subject underwent a complete blood count, and scoring assessments were performed using Pediatric Index of Mortality 3 (PIM 3), Pediatric Risk of Mortality III (PRISM III), and Pediatric Logistic Organ Dysfunction 2 (PELOD 2) criteria. Subjects were followed until they were discharged from PICU, with final outcomes recorded as survival or mortality.

Statistical analysis was performed using SPSS version 22.0. Receiver Operating Characteristic (ROC) curve analysis was employed to determine the optimal cut-off points for each scoring system in predicting mortality. Sensitivity, specificity, and area under the curve (AUC) were calculated, and each score's performance was validated using 95% confidence intervals. Post-ROC, each scoring variable was dichotomized according to the best-performing cut-off and

further analyzed using STATA SE 12.1 to determine diagnostic accuracy. Ethical approval for this study was granted by the Institutional Research and Ethics Committee.

RESULT AND DISCUSSION

During the research period, there were 60 children with acute respiratory distress syndrome. Of the 60 subjects, 16 subjects were observed until 28 days, and 44 subjects had visible outcomes before 28 days (19 died and 25 lived).

Receiving Operating Characteristic (ROC) analysis was carried out to obtain the ROC curve as a result of the trade-off between sensitivity and specificity of various cut-off points between scoring and outcome variables. The ROC procedure will get an Area Under Curve (AUC) value. The Area Under the Curve (AUC) value can be used to obtain visual and numerical information about the predictive value (AUC) of diagnostic tests in general. The AUC value of the PIM 3 score from the ROC curve was found to be an area of 0.96% (95% CI 0.90-1.0), indicating a good AUC value. The PIM 3 score cut point is 6.8 providing a sensitivity of 90.0% and a specificity of 95% for mortality in patients with acute respiratory distress syndrome.

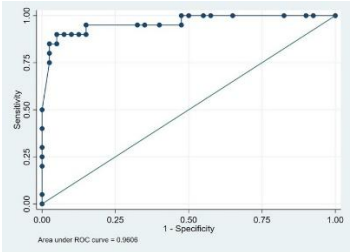

Figure 1. ROC curve of PIM 3 scores

The AUC value of the PRISM III score from the ROC curve was found to be 0.94% (95% CI 0.88-1.0), indicating a good AUC value. The PRISM III score cut point is ≥ 26, providing a sensitivity of 85.0% and a specificity of 100% for mortality in patients with acute respiratory distress syndrome.

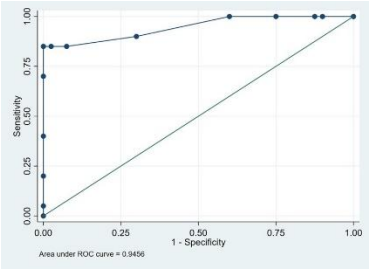

Figure 2. ROC curve of PRISM III scores

The AUC value of the PELOD 2 score from the ROC curve was an area of 0.90% (95% CI 0.79-1.0), indicating a good AUC value. The PELOD 2 score cut

point is ≥ 9 providing a sensitivity of 85.0% and a specificity of 100% for mortality in patients with acute respiratory distress syndrome.

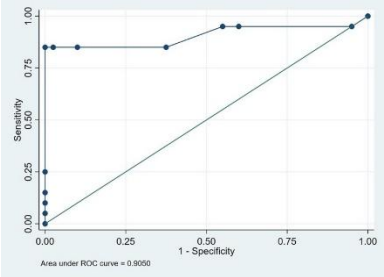

Figure 3. ROC curve of PELOD 2 score

A total of 60 research subjects were analyzed in this study with a mortality rate for pediatric acute respiratory distress syndrome of 34%. The characteristics of the research subjects are shown in Table 1.

Using PIM 3, PRISM III, and PELOD 2 scores requires considering several diagnostic test variables. This study assessed sensitivity, specificity, positive predictive value, negative predictive value, likelihood ratio (+), and likelihood ratio (-) in subjects. The PIM 3 score was found to have the highest level of sensitivity, but PRISM III and PELOD 2 had a higher level of specificity and positive predictive value. (Table 2)

Discussion

Sixty subjects were obtained in this study. The mortality rate obtained in this study was 33%. Death in pediatric acute respiratory distress syndrome patients generally occurs in patients with severe disease. In this study, the majority of patients with high PIM 3, PRISM III, and PELOD 2 suffered from severe degrees, 60%, 58.8%, and 64.7%, respectively. Orloff's research (2015) reported that the mortality rate in mild pediatric acute respiratory distress syndrome was 10-15%, while the severe degree was 35%. (Orloff, Turner, & Rehder, 2019)

The majority of subjects (56.6%) suffering from acute respiratory distress syndrome were male. The influence of gender on the incidence of acute respiratory distress syndrome in children is thought to be related to the physiology of lung development. Groeneveld et al. (2020) explained that since fetal development, female fetuses produce surfactant earlier than male fetuses and have fewer bronchi but experience bronchial maturation more quickly. Therefore, during childhood, especially at the age of 0-4 years, boys have smaller bronchiole diameters and a higher prevalence of asthma. (Groeneveld et al., 2020; Hermon, Dotzler, Brandt, Strohmaier, & Golej, 2018)

Table 1. Characteristics of research subjects

Variable	PIM 3		PRISM III		PELOD 2	
	≥ 6.8	< 6.8	≥ 26	< 26	≥ 9	< 9
Sex (%)						
Boy	7(35)	27(67.5)	6(35.2)	28(65.1)	5(29.4)	29(67.4)
Girl	13(65)	13(32.5)	11(64.7)	15(34.8)	12(70.5)	14(32.5)

Age(%)						
< 5 years old	9(45)	26(65)	8(47.0)	27(62.7)	8(47.0)	27(62.7)
≥ 5 years old	11(55)	14(35)	9(52.9)	25(37.2)	9(52.9)	16(37.2)
ARDS(%)						
Mild	0(0)	8(20)	0(0)	8(18.6)	0(0)	8(18.6)
Moderate	8(40)	22(55)	7(41.1)	23(53.4)	6(35.2)	24(55.8)
Severe	12(60)	10(25)	10(58.8)	12(27.9)	11(64.7)	11(25.5)
Nutritional St.(%)						
Malnutrition	10(50)	23(57.5)	9(52.8)	24(55.6)	8(46.9)	25(58)
Good nutrition	8(20)	15(37.5)	6(35.2)	17(39.5)	7(41.1)	16(37.2)
Over nutrition	2(10)	2(5)	2(11.7)	2(4.65)	2(11.7)	2(4.6)
Comorbidity(%)						
Yes	15(75)	17(42.5)	14(82.3)	18(41.8)	15(88.2)	17(39.5)
No	5(25)	23(57.5)	3(17.6)	25(58.1)	2(11.7)	26(60.4)
Oxygen Therapy(%)						
Invasive	16(80)	18(45)	13(76.4)	21(48.8)	10(58.8)	24(55.8)
Non-Invasive	4(20)	22(55)	4(23.5)	22(51.1)	7(41.1)	19(44.19)

Table 2. Diagnostic test for PIM 3, PRISM III and PELOD 2

Score	Sensitivity	Spesificity	Positive predictive value	Negative predictive value	*Likehood Ratio (+)*	*Likehood Ratio (-)*
PIM 3	90.0%	95.0%	90.0%	95.0%	18	0.10
PRISM III	85.0%	100.0%	100.0%	93.0%	N/A	0.15
PELOD 2	85.0%	100.0%	100.0%	93.0%	N/A	0.15

In this study, most of the patients were less than five years old. These results are similar to research by Ahmed et al. in 2019, which reported that the incidence of acute respiratory distress syndrome in pediatric intensive care unit patients in developing countries tends to be higher in the 1-3-year age group. The high prevalence of acute respiratory distress syndrome in children aged less than five years is related to the level of immune system maturation. (Ahmed, Azim, Nangialay, Haque, & Jurair, 2019)

Complete maturation of the immune system only occurs at puberty, so a child's younger age is related to immune system function that is not yet optimal. Lack of responsiveness of the immune response is related to the vulnerability of infants and children to various infections, including pneumonia, acute respiratory distress syndrome, and sepsis. (Randolph & McCulloh, 2014)

Comorbidities also influence the outcomes of patients with acute respiratory distress syndrome. As many as 75% of patients with a PIM score ≥ 6.8 had comorbidities, as did 82.3% of patients with a PRISM III score ≥ 26 and 88.2% of patients with a PELOD 2 score ≥ 9. This is supported by the study of Wang et al.

(2022) who stated that any comorbidity (p<0.001) significantly increases the incidence of mortality, especially sepsis comorbidity (p<0.001). A study by Kohne & Flori (2019) explained that immunodeficiency comorbidities also influence patient outcomes. As many as 8% of pediatric acute respiratory distress syndrome patients have cancer and 13% experience immunosuppression, with mortality rates of 51% and 46%, respectively.(Kohne & Flori, 2020; Wang et al., 2022)

The PIM 3 scoring system can be assessed in patients admitted to pediatric intensive care in the first hour of treatment. A study in Dubai by Malthora D, et al. in 2019 stated that this score was an adequate predictor of patient mortality in the intensive care unit (p <0.001). PIM-3 was found to have better calibration and discrimination capabilities compared to PIM-2. (Gupta, Sankar, Lodha, & Kabra, 2018; Ramazani & Hosseini, 2019; Shen & Jiang, 2021; Straney et al., 2013)

In this study, the AUC (Area Under Curve) value of the ROC curve (Receiveng Operator Characteristic) PIM 3 score was 0.96 (95% CI 0.90-1.0), indicating a good AUC. The PIM 3 score cut point is ≥ 6.8 providing 90% sensitivity and 95% specificity for mortality in acute respiratory distress syndrome patients. The study by Rahmatinejad, et al. in 2022 also examine the use of the PIM 3 score as a predictor of mortality in 2446 pediatric acute respiratory distress syndrome patients. In this study, the AUC was obtained at 0.82 (95% CI, 0.75-0.83). The cut point for PIM 3 score in this study was ≥ 2.5 with a sensitivity of 70% and a specificity of 66%. Another study by Nasser et al. (2020) using the PIM 3 cut point is > 9 with a sensitivity of 82.35% and a specificity of 97.56%. Meanwhile, the study by Chegini et al. (2022) used a cut point of ≥ 4 with a sensitivity and specificity of 100% (95% CI 56.09-100.00) and 81.51% (95% CI 11.80-79.76), respectively. Based on comparisons with other studies, it can be concluded that the PIM 3 cut point of ≥ 6.8 (sensitivity 90% and specificity 95%) in this study has a high and balanced level of sensitivity and specificity. (Chegini et al., 2022; M Nasser, Y Al-Sawah, R Hablas, & M Mansour, 2020; Rahmatinejad et al., 2022)

PRISM III is also used to assess the quality of care through the standardized mortality rate (SMR). This score has also been shown to have a significant relationship with patient mortality in pediatric intensive care units (p<0.001). (Mirza et al., 2020; Patki, Raina, & Antin, 2017; Pollack et al., 2016; Rsovac et al., 2022)

Based on the results of this research, the AUC (Area Under Curve) value of the ROC curve for the PRISM III score was 0.94 (95% CI 0.88-1.0), indicating good discrimination ability. The PRISM III score cut point in this study was ≥26 providing a sensitivity of 85% and a specificity of 100% for mortality in pediatric acute respiratory distress syndrome patients. A study by Rsovac, et al. in 2022 which also examined the use of the PRISM III score as a predictor of mortality in 70 pediatric acute respiratory distress syndrome patients treated in the pediatric intensive care unit obtained an AUC of 0.75 (95% CI, 0.64-0.87) and a cut point PRISM III score ≥ 13 with a sensitivity level of 64.1% and specificity of 80.6%. Anjali & Unnikrishnan's (2023) research compared sensitivity and specificity at two PRISM III score cut points. The study found that a PRISM III cut point ≥ 7 had a sensitivity of 100% and a specificity of 95%, while a PRISM III cut point ≥ 12 had a sensitivity of 100% and a specificity of 91%. Therefore, it can be concluded that the PRISM III

score cut point in this study is relatively larger, but has the highest level of specificity compared to other studies. (Anjali & Unnikrishnan, 2023; Rsovac et al., 2022)

Pediatric Logistic Organ Dysfunction (PELOD) is a tool used to determine the severity of organ dysfunction in critically ill children. A higher PELOD-2 score correlates with a higher number of organ failures and mortality rates. (Hendra, Runtunuwu, & Manoppo, 2010)

Based on the results of this research, the AUC (Area Under Curve) PELOD 2 score from the ROC (Receiver Operator Characteristic) area curve was 0.90 (95% CI 0.79-1.0), indicating a good AUC. The PELOD 2 score cut point is ≥ 9 providing a sensitivity of 85% and a specificity of 100%, for mortality in patients with acute respiratory distress syndrome. Similar research was conducted by Nguyen, et al. in 2020 which examined the use of the PELOD 2 score as a predictor of mortality in 306 patients treated at UPIA. In this study, the AUC was 89% (95% CI, 0.82-0.96). The PELOD 2 score cut point in this study was ≥ 11 which provided a sensitivity of 79.2% and a specificity of 87.1% for mortality in patients with acute respiratory distress syndrome. A PELOD score of 2 on the first day of treatment in the pediatric intensive care unit showed strong predictive value for describing organ dysfunction. (Nguyen et al., 2023)

Apart from sensitivity and specificity, assessing score performance should also consider the predictive value and likelihood ratio. In this study, the positive predictive value is defined as the ratio of patients who die compared to all patients with a score exceeding the cut point, while the negative predictive value is the ratio of patients who are alive compared to all patients with a score lower than the cut point. (Safari, Baratloo, Elfil, & Negida, 2015)

In this study, the PRISM III score (cut point ≥ 26) and PELOD 2 (cut point ≥ 9) had a higher level of specificity and positive predictive value compared to PIM 3. However, PIM 3 with a cut point ≥ 6.8 had the highest level of sensitivity and negative predictive value. The AUC of PIM 3 was also higher compared with the other two scores (the AUC of PIM 3, PRISM III, and PELOD 2 were 0.96 vs. 0.94 vs. 0.90, respectively). This indicates that the predictive ability of the PIM 3 score is better compared to the other two scores. Similar findings were put forward by Jung et al. (2018) who found that the AUC of PIM 3 was significantly greater than that of PIM 2 ($p<0.001$) and PRISM III ($p = 0.249$), indicating the superior predictive ability of PIM 3. (Jung et al., 2018)

This study has a limitation, namely the presence of other variables such as the use of inotropic agents, which as a whole can influence the mortality of children with acute respiratory distress syndrome, and this study cannot identify factors that influence the severity of acute respiratory distress syndrome.

CONCLUSION

This study aimed to evaluate the validity of the PIM 3, PRISM III, and PELOD 2 scores in predicting mortality in patients with acute respiratory distress syndrome in the pediatric intensive care unit. The results showed that the PIM 3 score had the highest sensitivity (90%) with a specificity of 95%, while PRISM III

and PELOD 2 had higher specificity, 100% each, but lower sensitivity (85%). Based on Area Under Curve (AUC) analysis, PIM 3 had the best predictive performance with an AUC value of 0.96 compared to PRISM III (0.94) and PELOD 2 (0.90). The contribution of this study provides a better understanding of the use of predictive evaluation tools for pediatric patient mortality, which may help in clinical decision-making and resource management in pediatric intensive care units. However, a limitation of this study is that it did not consider other factors, such as the use of inotropic agents, which may affect patient severity and mortality. Further research is recommended to explore additional factors that influence mortality prediction, as well as the validation of this score in a larger and diverse population. In addition, developing more comprehensive predictive methods may improve the accuracy and efficiency of patient care.

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