Pediatric Risk of Mortality (PRISM III-24) performance in a Greek pediatric intensive care unit

Volakli E MD, PhD, Mantzafleri PE MD, Sdougka M MD

ABSTRACT

Pediatric Risk of Mortality (PRISM III-24) performance in a Greek pediatric intensive care unit

Volakli E, Mantzafleri PE, Sdougka M

The purpose of this study was to investigate the performance of the Pediatric Risk of Mortality (PRISM III–24) in a Greek pediatric intensive care unit (PICU). We prospectively followed 300 PICU patients in an observational cohort study. PRISM III-24 performance was assessed in the whole population and in 4 preselected groups (infants, patients with length of PICU stay > 4 days, patients with co-morbidities, ventilated patients) with standard discrimination and calibration methods. Efficiency (on admission) was defined as admission of patients with mortality risk >1%, while effectiveness was determined as standardized mortality ratio (SMR). The area under the receiver operating curve (AUC) showed good discrimination of PRISM III-24 score (AUC 0.892, 95%CI 0.821-0.963) and PRISM III-24 predictive model (AUC 0.900, 95%CI 0.836-0.964). Hosmer-Lemeshow goodness-of-fit test showed good calibration of PRISM III-24 score (χ^2 (8) =1.716, p = =0.989) and PRISM III-24 predictive model (χ^2 (8) = 8.294, p = 0.405). Good performance was also found in the 4 preselected groups (AUC always>0.835, p values of the goodness-of-fit test always > 0.434). Efficiency was 76.7%, predicted PICU mortality was 11.1%, observed PICU mortality at discharge was 9.7%, and the SMR was 0.997 (95% CI 0.67-1.43). PRISM III-24 performed well in our population showing high discrimination and calibration capabilities. Mortality was higher than in relevant studies, probably due to case mix, patient characteristics and the distinct PICU policy of our country. However, efficiency and effectiveness were met by an international standard.

PEDIATRIC INTENSIVE CARE UNIT,
HIPPOKRATIO GENERAL HOSPITAL,
THESSALONIKI, GREECE

INTRODUCTION

PRISM III is a well validated, third generation scoring system based on data of 11,165 patients in 32 Pediatric Intensive Care Units (PICUs) in the United States[1-3]. Predictions of mortality at PICU discharge can be made by using either the first 12 hrs (PRISM III-12) or the first 24 hrs (PRISM III-24) of physiologic, demographic, and diagnostic data. PRISM III-12 is used primarily in quality studies due to its relatively early application while PRISM III-24 is more accurate for individual patient mortality risk assessment. The full description of the PRISM III score and the development of the PRISM III predictive mortality model can be found elsewhere[1].

Development of pediatric predictive mortality models introduced two new terms relative to PICU function; efficiency and effectiveness of care[4-7]. Efficiency is the rate of PICU patients with estimated mortality risk>1% and /or the patients needed ICU-specific therapy during their stay e.g., mechanical ventilation and/or inotropic use, while efficiency rate of > 80% could be a reasonable goal for a unique PICU[6]. Effectiveness is defined according to the Standardized Mortality Ratio (SMR) e.g., the ratio of observed to predicted mortality[8]. Values>1 suggest a higher than predicted mortality, whereas values<1 suggest a better than predicted performance.

One possible drawback of predictive mortality models is that they could be population sensitive, so validation studies are necessary before application in another setting. In our country, so far there is not any scoring system especially developed and/or validated for use in PICU patients. The primary objective of this study was to determine the suitability of PRISM III-24 for estimating the severity of the disease and the probability of death of Greek PICU patients. The secondary objectives were to assess how the performance of our unit in terms of efficiency and effectiveness compares to an international standard.

This article reports the PRISM III-24 validity results, while the full description of the study population and the outcome has been done previously[9].

MATERIALS AND METHODS

Setting

The Department of Pediatric Intensive Care in Hippokratio General Hospital of Thessaloniki, Greece, is a multidisciplinary 8-bed PICU of a tertiary 1000-bed hospital which serves an estimated population of Northern Greece of 3,500,000 millions. It provides admission to infants with age of > 40 days to children up to 14 years, in all diagnostic categories, except postoperative congenital heart diseases patients due to lack of pediatric cardiothoracic depart-

ment in the area. Beyond basic monitoring there are capabilities for invasive hemodynamic monitoring of arterial pressure, central venous pressure and pulse contour cardiac output measurements (PiCCO, ©Pulsion Medical Systems AG, Munich, Germany). All modes of care are available, including standard ventilation, high-frequency oscillator ventilation, renal replacement therapies, and e.t.c., with the exception of extracorporeal membrane oxygenation. There is a full board Director, 24hrs/7days full coverage of a Pediatric Intensivist and a nurse to patient ratio ranges between 1:2 in morning shifts to 1:3 in afternoon and night shifts. Laboratory, radiological and operational facilities are 24hrs available, while there is on call coverage of all pediatric subspecialties. On discharge patients are transferred to pediatric wards, as there is no intermediate step down unit available.

Patients

300 consecutive PICU patients were prospectively recorded according to exclusion criteria which were: patients with missing data and patients who died during the first 2 hrs of admission, because their PICU stay was too short to be connected to the outcome. In case of readmission, the patient was recorded only during the first admission. Due to the observationnal character of the study which didn't require any deviation from routine medical care, institutional review board approval was waived and informed consent was not required. Patients were followed until death in the PICU, or discharge. All deaths happened in the PICU; withdrawal of life support is not a routine practice in the unit because of the absence of legal guidelines on this issue in our country.

Data collection

The following data were collected prospectively: Demographics, co-morbidities, elective/ /emergency status, operative status, admission source, previous pediatric PICU admission, selected critical care modalities, PICU length of stay (LOS) and the outcome at PICU discharge. Clinical and laboratory data needed to calculate the PRISM III-24 score were reported as the worst value within 24 hrs after PICU admission. Evaluation of neurologic status was made using the pediatric version of Glasgow Coma Scale[10] and patients with GCS <8 were recorded as suffered from coma. In case of trauma, its severity was estimated through Injury Severity Score[11].

Statistical analysis

Descriptive statistics were computed for all study variables. Discrete variables were expressed as counts (percentages) and continuous variables as means ± standard deviation (SD). Prism III-24 predicted PICU mortality rate was estimated with the free for 60 days PICUEs version 3.2 software trial (PICUEs v 3.2, Children's National Medical Center, Wa-

shington, USA). We chose to assess the performance of the PRISM III-24, because it was found to be more accurate for individual patient mortality risk assessments. Because the algorithms for the estimation of mortality risk through PRISM III-24 predictive model are not always available, whether the estimation of PRISM III-24 score could be done manually under all circumstances, we assessed both the performance of the score as well as the performance of the model, in the whole population and in 4 preselected groups (infants, patients with LOS>4 days, patients with co-morbidities, ventilated patients).

Discrimination was assessed by the area under the receiver operating characteristics curve (AUC) with 95% confidence interval (CI) and Calibration was examined using the Hosmer-Lemeshow goodness-of-fit test[12-13]. Reliability of data collection was examined with a random recollection of 30 cases by a second investigator through the interobserver k score[14]. Efficiency (on the day of admission only) was evaluated through the percentage of patients who had a mortality risk >1%, while effectiveness was estimated through SMR with 95% CI.

Data were analyzed using SPSS 11.0 for windows (SPSS, Chicago, IL). Values of $p < 0.05$ were considered statistically significant.

RESULTS

Among 382 consecutive patients, 300 (196 boys/104 girls), aged 54.26 ± 49.93 months, were eligible for the study. 82 patients were excluded, 40 due to readmission and 42 due to insufficient data. Most patients had an excellent health prior PICU admission, but quite a lot (124pts,41.3%) suffered from co- morbidities. The vast majority (277pts, 92.3%) was pediatric emergencies and two thirds of them (204pts,68%) were admitted from referral hospitals (Table 1). The prominent diagnosis at admission was respiratory failure (67pts, 22.3%) and thereafter followed head trauma (46pts,15.3%), seizures (41pts,13.7%), coma (29pts, 9.7%), postoperative care (23pts,7.7%), polytrauma (21pts,7%), accidents (16pts, 5.3%), sepsis-septic shock (16pts, 5.3%), cardiovascular diseases (14pts, 4.7%), metabolic diseases (10pts,3.3%), multiple organ failure syndrome (9pts,MOFS, 3%) and miscellaneous diseases (8pts, 2.7%).

Twenty-nine patients died in the PICU given an observed mortality rate of 9.7%. Main mortality causes were severe traumatic brain injury (7pts, 24.1%) and multiorgan failure (9pts, 31%), while two patients (6.9%) died from intractable cardiac arrest in the ground of congenital heart diseases.

Mean value of PRISM III-24 score was 8.97 ± 7.79 and mean predicted mortality rate was

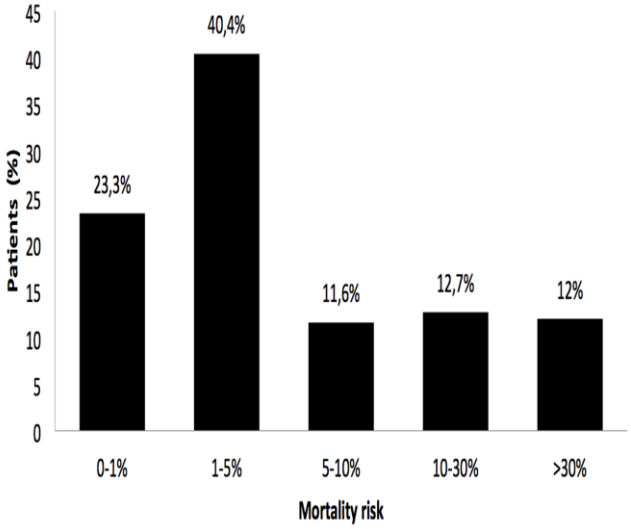
11.16%. The distribution of mortality risk according to PRISM III-24 predictive model is shown in Figure 1.

Table 1. Patients' characteristics

	All patients (*n* = 300)
Age, months	54.26 ± 49.93
Infants	85 (28.3)
Male gender	194 (64.6)
Co morbidities	124 (41.3)
Source of admission	
Referral in town hospital	81 (27.0)
Referral hospital in remote areas	123 (41.0)
Hospital floor	96 (32.0)
Emergency patients	277 (92.3)
Surgical patients	23 (7.7)
PRISM III-24 score	8.97 ± 7.79
GCS score	11.26 ± 3.38
ISS score[a]	20.08 ± 11.53
Efficiency	76.7%
PICU modalities	
Mechanical ventilation at admission	175 (58.3)
Mechanical ventilation during stay	202 (67.3)
Arterial catheterization	165 (55.0)
Central venous catheterization	102 (34.0)
Pulse contour cardiac output	15 (5.0)
Inotropic use, patients	52 (17.3)
Renal replacement therapies	6 (2.0)
Length PICU stay(days)	8.85 ± 23.28
Predicted PICUmortality	11.16
Observed PICUmortality	29 (9.7)
Standardized Mortality Ratio (95% CI)	0.99(0.67-1.43)

Variables are described as n (%) or mean (standard deviation), PRISM: Pediatric Risk of Mortality, GCS: Glasgow Coma Scale, ISS: Injury Severity Score, PICU: Pediatric Intensive Care Unit, CI: Confidence Interval, [a]Trauma patients only.

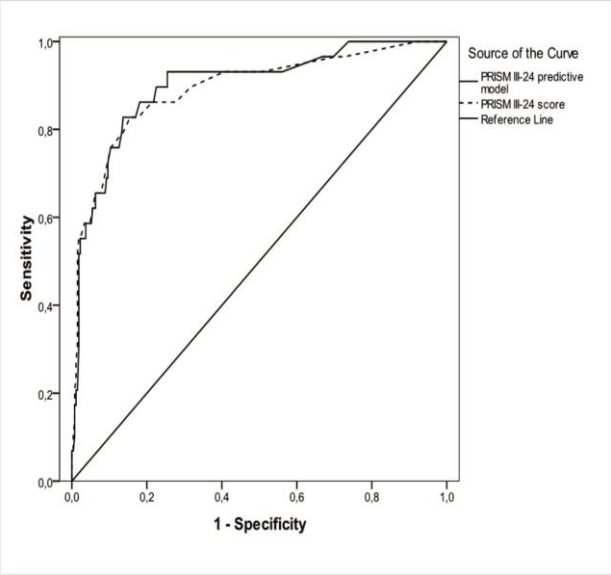
Figure 1. Mortality risk distribution according to PRISM III-24 predictive model



The majority of our patients (230pts, 76.7%) had a mortality risk>1% and almost one fourth of them (74pts, 24.7%) had a mortality risk >10%. According to patients with mortality risk>1%, efficiency on admission was 76.7% whereas efficiency based on ICU-specific therapy during PICU stay was 69.3%.

ROC curves of PRISM III-24 score and PRISM III-24 predictive model with the additional risk factors, computed for the whole population (n=300; deaths 29) are shown in Figure 2. Both curves showed very good discrimination capability; PRISM III-24 score AUC was 0.892 (95%CI: 0.821-0.963) whereas PRISM III-24 predictive model AUC was 0.900 (95% CI: 0.836-0.964). Interobserver k score of reliability was 1.

Figure 2. Receiver operating characteristics curves for the whole population (n=300; deaths = 29).



Solid line, PRISM III-24 predictive model with the additional risk factors (AUC = 0.900, p = 0.001, 95% CI: 0.836 – 0.964); Dashed line, PRISM III-24 score (AUC = 0.892, p = 0.001, 95% CI: 0.821 – 0.963). PRISM: Pediatric Risk of Mortality, CI: Confidence Interval.

Hosmer-Lemeshow goodness-of-fit test for the whole population showed good calibration of PRISM III-24 score (χ^2 (8)=1.716, p = 0.989) and PRISM III-24 predictive model (χ^2 (8)= 8.294, p = 0.405), as shown in Table 2 and 3. For the entire sample, SMR for PRISM III-24 score was 1 (95% CI: 0.67-1.44) and SMR for PRISM III-24 predictive model was 0.997 (95% CI: 0.67-1.43). Effectiveness of our unit, as assessed by SMR through PRISM III-24 predictive model, was 0.997.

Table 2. Hosmer-Lemeshow goodness-of-fit test of PRISM III-24 score

PRISM III-24		Alive		Dead		SMR (95%CI)
Step	**Score**	**Obs**	**Exp**	**Obs**	**Exp**	
1	0-2	21	20.8	0	0.2	0 (0- 18.2)
2	3	53	53.2	1	0.8	1.2 (0.03-7)
3	4	6	5.9	0	0.1	0 (0-34.8)
4	5	54	53.8	1	1.2	0.8 (0.02-4.7)
5	6-7	27	26.2	0	0.7	0 (0-4.7)
6	8	24	24	1	0.9	1 (0.03-5.9)
7	9-10	28	27.5	1	1.4	0.7 (0.02-3.7)
8	11-14	30	30.1	3	2.8	1 (0.2-3.0)
9	15-23	24	24.2	7	6.7	1 (0.4-2.1)
10	>24-74	4	5.1	15	13.9	1 (0.6-1.7)
Total		271	271	29	29	1 (0.6-1.4)

Obs:observed, Exp:expected, PRISM: Pediatric Risk of Mortality, χ^2 (8) = 1.716, p = 0.989, SMR: Standardized Mortality Ratio, CI: Confidence Interval

Good performance of PRISM III-24 predictive model was also found in the 4 preselected groups (infants, patients with LOS>4days, patients with co-morbidities, ventilated patients) where ROC areas were always>0.835 and p values of the goodness-of-fit test were always > 0.434, as shown in Table 4.

Table 3. Hosmer-Lemeshow goodness-of-fit test of PRISM III-24 predictive model

Mortality risk (%)		Alive		Dead		SMR (95%CI)
Step		**Obs**	**Exp**	**Obs**	**Exp**	
1	0 – 0.8	28	27.3	0	0.7	0 (0-5.2)
2	>0.8 - 1	42	40.9	0	1.1	0 (0-3.3)
3	>1 -1.6	20	20.4	1	0.5	1.7 (0.05-9.9)
4	>1.6-1.7	29	29.1	1	0.8	1.2 (0.03-6.8)
5	>1.7- 2.7	27	26.2	0	0.7	0 (0-4.8)
6	>2.7 -3.8	32	31	0	0.9	0 (0-3.7)
7	>3.8 -7.7	32	31.8	1	1.2	0.8 (0.02-4.6)
8	>7.7 -17	27	29.3	4	1.6	2.3 (0.6-6.1)
9	>17 -38	24	25.6	6	4.4	1.36 (0.5-2.9)
10	>38 -100	10	9.19	16	16.8	0.9 (0.5-1.5)
Total		271	271	29	29	0.9 (0.6-1.4)

Obs:observed, Exp:expected, PRISM: Pediatric Risk of Mortality, χ^2 (8) = 8.294, p = 0.405, SMR: Standardized Mortality ratio, CI: Confidence Interval

Table 4. Performance of PRISM III-24 predictive model in preselected subgroups

Subgroups	All patient (*n* = 300)	AUC (95% CI)	Hosmer-Lemeshow χ^2	
			df	*p*
Infants *n (%)*	85(28.3)	0.8(0.7-0.9)	8	0.6
LOS > 4 days *n (%)*	123(41)	0.8(0.7-0.9)	8	0.4
Co morbidities *n (%)*	124(41.3)	0.8(0.7-0.9)	7	0.6
Ventilated patients *n (%)*	202(67.3)	0.8(0.8-0.9)	7	0.45

PRISM: Pediatric Risk of Mortality, AUC: Area Under Receiver Operating Characteristics curve, CI: Confidence interval, df: degrees of freedom, LOS: Length Of Stay in the unit

DISCUSSION

We assessed the suitability of PRISM III-24 in Greek PICU patients and found that PRISM III-24 is displaying the same relationship between physiological status and outcome as the reference population of USA patients; consequently it could be used in a different health system as a valid tool for estimating the severity of critical illness and the probability of death. Moreover, through the application of PRISM III-24, we were able to examine the performance of our PICU, which was found comparable to international standards.

The validation of PRISM III-24 was done by standard discrimination and calibration methods. For the entire sample, ROC curves showed very good discrimination of both PRISM III-24 score (AUC 0.892) and PRISM III-24 predictive model with the additional risk factors (AUC 0.9). Hosmer-Lemeshow goodness-of-fit test showed an overall good calibration of PRISM III-24 score (p = 0.989) and PRISM III-24 predictive model (p = 0.405) as well.

SMR was more uniform in PRISM III-24 score levels compared to PRISM III-24 predictive model risk intervals. There was a SMR of 1.78 in step 3 of the model (mortality risk of 1.1-1.6%) due to the death of child who was

quite stable on admission but suffered from congenital heart disease and died from intractable ventricular tachycardia. There was also a high SMR of 2.39 in step 8 of the model (mortality risk 7.8-17%) due to the death of 4 children, 3 of whom had underlying illness (inborn error of metabolism, lymphoma, and congenital heart disease). These findings couldn't be attributed to PRISM III-24 weakness as under prediction; predictive models can't be used to predict the outcome of individual patients as underlying illness did play a role in the outcome of those patients and led them to a higher than predicted mortality. Calibration was very good in higher PRISM III score levels (steps 8, 9, and 10) and higher mortality risk strata of PRISM III predictive model (steps 9 and 10). However, due to lack of deaths in some lower scores and risk strata steps, we should interpret our findings about calibration of these steps cautiously.

Good performance of PRISM III-24 predictive model was also found in the 4 preselected groups, a fact that improves the significance of our results. Infancy had been connected with bad discrimination[15,16] and calibration[16,17] in initial PRISM performance, a problem that it seems solved now with the better age adjustment in PRISM III physiologic parameters. Apart from a reference of poor calibration of initial PRISM in patients with LOS > 4 days[17], we speculated that there was a change of bad PRISM III performance in patients with LOS > 4 days, since their outcome could had been influenced by other unpredictable factors related to PICU stay. Our findings didn't support this hypothesis as PRISM III-24 showed good performance in those patients too; indicating that physiologic disruption during the first 24 hrs remains the major outcome factor. Poor calibration of initial PRISM is reported in patients with underlying illness as well[15], a finding that wasn't confirmed by our study, which suggests that co morbidities don't affect the general performance of PRISM III-24. We speculated also that patients under mechanical ventilation were possible candidates for bad PRISM III performance because mechanical ventilation is a mortality risk factor in PICU patients[18], yet our findings didn't support this hypothesis either, as PRISM III performed well in this subgroup too, signifying again that disarrangement of physiologic status is the key outcome parameter.

We found that PRISM III-24 is a well validated model on the whole population, and in the 4 preselected subgroups of Greek PICU patients. Our results are comparable to values reported by Pollack et al., in the original PRISM III study (PRISM III-24 development, AUC 0.958, goodness-of-fit *p* value 0.1374; PRISM III-24 validation, AUC 0.944, goodness-of-fit *p* value 0.5504). Interestingly, the characteristics of the study site make its performance si-

milar even in a different health system, thus allowing international comparisons. Our findings are also supported by relevant studies that examined the performance of PRISM III-24 in a population other than the originally studied in Europe and elsewhere[19-22]. Gemke et al., in their study of 303 Dutch PICU patients found that PRISM III is an adequate indicator of mortality probability for heterogeneous patients groups in pediatric intensive care (both PRISM III-12 and PRISM III-24 AUC 0.78, goodness-of-fit *p* value 0.21)[19]. Choi et al., in 303 PICU patients in Hong Kong, reported also that the predicted PRISM III mortality correlated well with the observed mortality (PRISM III-24 AUC 0.912, SMR 0.78)[20]. Further, very important validation comes from a multicenter high population study of Brady et al., of 10,197 United Kingdom PICU patients [21]. Brady and coauthors assessed different mortality prediction tools, and after estimation of UK-specific coefficients, they concluded that PRISM III-12 and PRISM III-24 had good discriminatory power and satisfactory calibration. Finally, Bilan et al., in their study of 221 PICU patients in Iran, reported also high validation of PRISM III-24 (AUC 0.898, goodness-of-fit *p* value 0.161)[22].

There is only one study in the literature so far that reported poor calibration of PRISM III[23]. Slater and Shann, in their study of 26,966 PICU patients in Australia and New Zealand, reported good discrimination capability of PRISM III (AUC 0.93) but poor calibration, as they found that PRISM III over predicted death, predicting 130% of observed deaths. Although their study suffered from some limitations (lack of independently validation of the Pediatric Index of Mortality PIM 2, two phase study where PIM 2 and PRISM III were applied in different populations) the authors concluded that PIM 2 is the most suitable mortality prediction model in Australia and New Zealand.

Severity of critical illness in our population was higher than the reported ones[4-5,24-25]. Patients with mortality risk lower than 1% represented only 23.3% of our sample, compared to values from 15.8% to 67.5%, and in particular 64.8% in the training sample of PRISM III study. On the contrary, more patients had a mortality risk>10% (24.7%vs8.7% in PRISM III). Patients with mortality risk<1% are considered low risk patients; their proportion is crucial in outcome studies and indicative of PICU efficiency. Efficiency of our unit ranged from 69.3% based on ICU-specific therapy to 76.7% according to mortality risk > 1%; both values being within the reference values of 32.5% to 84.2%[1,4-6,24-25], and close to the efficiency goal of 80% set by Pollack at al[6].

Prism III-24 predicted mortality rate was 11.16% and the observed mortality rate was

9.7%, relatively high compared to reference values of 4.2% to 9.13%[1,4-6,18-22,23,26-27]. PICU's main goal is the reduction in mortality, yet special consideration should be given to mortality studies; reports on mortality rate alone, without risk adjustment, could make their results misinterpreted[28]. In our study, the high proportion of emergencies and admissions from remote areas, the case mix with low percentage of surgical and high percentage of trauma patients, the high severity of illness and the high frequency of mechanical ventilation could account for the relative high but in accordance with the severity of illness mortality. PICU effectiveness, based on SMR of PRISM III-24 predictive model was 0.997.

A significant limitation of our study is that it is a single centre study, and such as, it might be considered as not being representative of the Greek PICU population. However, the multidisciplinary character of the unit and the big geographical area that it serves makes this limitation less possible. A further limitation is the fact that the relatively small number of patients studied is likely to interfere with accurate application of the Hosmer-Lemeshow goodness-of-fit test and precluded further validation of PRISM III-24 in other preselected subgroups e.g., more age or diagnostic categories. Future thoughts could include the extension of the study in the same and other Greek PICUs, so that potential multicenter higher population studies could offer an even better assessment of PRISM III-24 performance and the establishment of a national standard.

In conclusion, we validated an international prediction model for use in pediatric intensive care patients that compares critical illness severity to mortality risk and found a very good performance in predicting the overall mortality, on the whole population and in 4 preselected subgroups of Greek PICU patients. Mortality was higher than in relevant studies, probably due to case mix, patient characteristics and the distinct PICU policy of our country. However, efficiency and effectiveness were comparable to international standards. This is to our knowledge the first study of this kind on a Greek PICU population and could serve as a basis to create a national standard for estimation of the severity of critical illness and outcome prediction in Greek critically ill children. Application of international prediction models at national levels could allow international PICU comparisons and offer a better insight in pediatric intensive care.

Acknowledgments We thank Dr. M. Pollack for the kind free of charge offer of PRISM III algorithms.

REFERENCES

1. Pollack MM, Patel KM, Ruttiman UE. PRISM III: an updated Pediatric Risk of Mortality score. Crit Care Med 1996; 24:743-752
2. Pollack MM, Ruttiman UE, Getson PR. Pediatric risk of mortality (PRISM) score. Crit Care Med 1988;16:1110-1116
3. Yeh TS, Pollack MM, Ruttiman UE, et al.Validation of a physiologic stability index for use in critically ill infants and children. Pediatr Res 1984;18:445-451
4. Gemke RJ, Bonsel GJ. Comparative assessment of pediatric intensive care: a national multicenter study. Pediatric Intensive Care Assessment of Outcome (PICASSO) Study Group. Crit Care Med 1995; 23:238-245
5. Gemke RJ, Bonsel GJ, van Vught AJ. Effectiveness and efficiency of a Dutch pediatric intensive care unit: validity and application of the Pediatric Risk of Mortality score. Crit Care Med 1994; 22:1477-1484
6. Pollack MM, Getson PR, Ruttimann UE, et al. Efficiency of intensive care. A comparative analysis of eight pediatric intensive care units. Jama 1987; 258:1481-1486
7. Ruttimann UE, Patel KM, Pollack MM. Length of stay and efficiency in pediatric intensive care units. J Pediatr 1998; 133:79-85
8. Moreno R. Performance of the ICU: Are we able to measure it? In:Vincent JL (ed) Yearbook of Intensive Care and Emergency Medicine. Springer-Verlag, Berlin, 1998; pp 729-743
9. Volakli EA, Sdougka M, Drossou-Agakidou V, et al. Short-term and long-term mortality following pediatric intensive care. Pediatrics International 2012;54:248-255,
10. Reilly PL, Simpson DA, Sprod R, et al. Assessing the conscious level in infants and young children: a paediatric version of the Glasgow Coma Scale. Childs Nerv Syst 1998; 4:30-33
11. Baker SP, O'Neill B, Haddon W, Jr., et al. The injury severity score: a method for describing patients with multiple injuries and evaluating emergency care. J Trauma 1974;14:187-196
12. Hanley J, McNeil B. The meaning and use of the area under a receiver operating characteristic curve. Radiology 1982; 143:29-36

13. Hosmer D, Lemeshow S. Applied logistic regression. John Wiley & Sons, Inc, New York 1989
14. Soeken KL, Prescott PA. Issues in the use of kappa to estimate reliability. Med Care 1986; 24:733-744
15. Thurkal A, Lodha R, Irshad M, et al. Performance of Pediatric Risk of Mortality (PRISM), Pediatric Index of Mortality (PIM), and PIM2 in a pediatric intensive care unit in a developing country. Pediatr Crit Care 2006; Med 7:356-361
16. Wells M, Hons R-F, Jacinto F, et al. Poor discriminatory perfor-mance of the Pediatric Risk of Mortality (PRISM) score in a South African intensive care unit. Crit Care Med 1996; 24:1507-1513
17. Bertolini G, Ripamonti D, Cattaneo A, et al. Pediatric Risk of Motality: An assessment of its performance in a sample of 26 Italian intensive care units. Crit Care Med 1998; 26:1427-1432
18. Tan GH, Tan TH, Goh DY, et al. Risk factors for predicting mortality in a paediatric intensive care unit. Ann Acad Med Singapore 1998; 27:813-818
19. Gemke RJ, van Vught J. Scoring systems in pediatric intensive care: PRISM III versus PIM. Intensive Care Med 2002; 28:204-207
20. Choi KM, Ng DK, Wong SF, et al. Assessment of the Pediatric Index of Mortality (PIM) and the Pediatric Risk of Mortality (PRISM) III score for prediction of mortality in a paediatric intensive care unit in Hong Kong. Hong Kong Med 2005; 11:97-103
21. Brady AR, Harrison D, Black S, et al. Assessment and optimization of mortality prediction tools for admissions to pediatric intensive care in the United Kingdom. Pediatrics 2006; 117:e733-742
22. Bilan N, Galehgolab B, Emmadaddin A, et al. Risk of mortality in pediatric intensive care unit, assessed by PRISM III. Pak J Biol Sci 2009; 12:480-485
23. Slater A, Shann F. The suitability of the Pediatric Index of Mortality (PIM), PIM2, the Pediatric Risk of Mortality (PRISM), and PRISM III for monitoring the quality of pediatric intensive care in Australia and New Zealand. Pediatr Crit Care Med 2004; 5:447-454
24. Martinot A, Leteurtre S, Grandbastien B, et al. Characteristics of patients and use of resource in French pediatric intensive care units. Le groupe

francophone de Reanimation et urgences pediatriques. Arch Pediatr 1997; 4:730-736

25. Seferian EG, Carson SS, Pohlman A, et al. Comparison of resource utilization and outcome between pediatric and adult intensive care unit patients. Pediatr Crit Care Med 2001; 2:2-8
26. Shann F, Pearson G, Slater A, et al. Paediatric index of mortality (PIM): a mortality prediction model for children in intensive care. Intensive Care Med 1997; 23:201-217
27. Slater A, Shann F, Pearson G. PIM 2: a revised version of the Pediatric Index of Mortality. Intensive Care Med 2003; 29:278-285
28. Marcin JP, Pollack MM. Review of the methodologies and applications of scoring systems in neonatal and pediatric intensive care. Pediatr Crit Care Med 2000; 1:20-27

Keywords: Intensive care unit, pediatric Mortality, Pediatric risk of mortality, PRISM III-24, Outcome, Efficiency, Effectiveness

Corresponding author:

Eleni A. Volakli
N. Xylouri 26, 56626, Thessaloniki, Greece
Tel: 2301210519, 2310892441, mobile: 6936251219
email: elenavolakli@gmail.com