

## Pediatric index of mortality 2 scores in pediatric intensive care unit patients

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### Abstract

**Background** Comprehensive care for critically ill children in the pediatric intensive care unit (PICU) is done with the aim of achieving good outcomes. Severe disease in children is characterized by disruption of homeostatic processes, and can be evaluated by mortality scoring methods. There are several mortality scoring methods which can be used to predict mortality in children, the pediatric risk of mortality (PRISM) and pediatric index of mortality (PIM) are the most preferably used among all. The pediatric index of mortality 2 (PIM2) is a key mortality prediction model for children receiving treatment in intensive care units, but its use has not been well validated in Indonesia.

**Objective** To evaluate the performance of PIM2 model in PICU patients.

**Methods** This cross-sectional study was conducted on PICU patients at Sanglah Hospital from November 2012 to April 2013. Patients underwent PIM2 scoring during their admission. The predictive ability of PIM2 scoring for patient mortality was analyzed using ROC curve.

**Results** A total of 54 patients were included in this study, of whom 8 (14.8%) died. Discrimination between survival and death was assessed by the area under the receiver operating characteristic curve and found to be 0.81 (95% CI 0.59 to 1.03). Sensitivity was 75 (95% CI 36 to 96)% and specificity was 98 (95% CI 87 to 99)%. The PIM2 cut off value was  $\geq -0.99$ .

**Conclusion** The PIM 2 model has a good discriminatory power and calibration for predicting the mortality of children admitted to PICU and therefore is recommended for routine use in clinical practice. [Paediatr Indones. 2016;56:43-7.].

**Keywords:** pediatric index of mortality, children, mortality, pediatric intensive care unit

There are two key models to predict mortality among children admitted to intensive care units, the pediatric risk of mortality (PRISM) and the pediatric index of mortality (PIM).<sup>1,2</sup> Both models are used in clinical practice or research to assess quality of care and to determine severity of illness in pediatric intensive care units (PICUs).<sup>1</sup> The PRISM was revised into the PRISM III in 1996, while the PIM was revised into the PIM2 in 2002, adjusted to the most recent improvements in pediatric critical care outcomes.<sup>3,4</sup> Although PRISM and PIM have been used to predict mortality in ICU settings, the simulated model does not always match real clinical situations in various settings, and, therefore, require validation.<sup>5-7</sup>

In comparisons of the PRISM III and PIM2 models, PIM2 was regarded to be a better tool because it is simpler and only requires ten variables collected at the time of ICU admission, compared to 17 variables included in the PRISM III model.<sup>3,4</sup> To our knowledge, mortality scores are not commonly used in Indonesia, partially due to lack of validation in Indonesian population. Therefore, we aimed to

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evaluate the application of PIM2 model in Indonesian PICU patients.

## Methods

This prospective cohort study was conducted in the PICU of Sanglah Hospital, Bali, Indonesia, from November 2012 to April 2013. Subjects were included consecutively. The inclusion criteria for this study were all critically ill pediatric patients hospitalized in the PICU, and whose parents provided informed consent. Exclusion criteria were as follows: 1) death in less than 2 hours after PICU admission or discharge from PICU within 24 hours after admission; 2) brain death at the time of PICU admission; 3) age <30 days or >12 years; 4) implementation of cardiopulmonary resuscitation (CPR) at the emergency department (ED) without spontaneous circulation for at least 2 hours; and 5) transfer to another ICU.

The minimum required sample size was calculated using the formula for diagnostic test in a single proportion,<sup>8</sup> with a 28% prevalence of mortality based on a previous study,<sup>6</sup> type I error of 0.05, and d of 0.2. The minimum sample size required was estimated to be 46 subjects.

Mortality outcome and other data were obtained each day in PICU, while PIM2 scores were assessed within 1 hour of PICU admission by attending physicians. Kappa test was performed to evaluate test-retest reliability, and found to have a coefficient of 1. Daily data collected included non invasive blood pressure, pupil diameter, blood gas analysis [arterial oxygen pressure (PaO<sub>2</sub>), base excess (BE)], fraction of inspired oxygen (FiO<sub>2</sub>), as well as assessment of high risk vs. low risk diagnoses. Pupil diameter was defined as the diameter of each pupil in millimeters when illuminated by a pen light from the outer perimeter to the center of the eye, and categorized as > 3mm or ≤ 3mm. Blood gas analysis (BGA) was performed at the Sanglah Hospital Laboratory by technicians who were blinded to subjects' PIM2 scores. The FiO<sub>2</sub> value was defined as that measured by the continuous positive airway pressure (CPAP)/ventilator machine or that used through any other respiratory devices (nasal canula, mask, or headbox).

Elective admission to the PICU was defined to be the PICU admission of critically ill patients which

could have been delayed for more than six hours without harm, and categorized as yes or no. Recovery from surgery or procedure was defined to be the healing process after the surgery or procedure, including cardiac catheterization, and categorized as yes or no. Treatment after heart bypass surgery was defined to be the stabilization of acute complications that may have occurred after surgery, and categorized as yes or no.

A high risk diagnosis, established before PICU admission, was defined to be a high risk of death, which included cardiac arrest prior to PICU admission (including cardiac arrest within or outside the hospital), severe immune deficiency, leukemia/lymphoma after first induction, spontaneous cerebral hemorrhage [e.g., bleeding due to aneurysm or arterial venous (AV) malformation, but not including traumatic brain bleeding, intracranial hemorrhage, or subdural hemorrhage], cardiomyopathy/myocarditis, hypoplastic left heart syndrome (only cases in which the Norwood or equivalent procedure was performed), HIV infection, liver failure (acute and chronic, including liver transplant patients), and neuro-degenerative disorders. The score sheet contained 10 categories numbered 1-10, with an ordinal scale. A low risk diagnosis, established before PICU admission, was defined to be a low risk of death. Diseases and conditions in this category included asthma, bronchiolitis, croup, obstructive sleep apnea (including patients hospitalized following adenoidectomy and tonsillectomy), and diabetic ketoacidosis. The score sheet contained 10 categories numbered 0-5, with an ordinal scale.

To assess the predictive ability of PIM2 on subjects' mortality, we constructed an ROC and calculated corresponding sensitivity and specificity, predictive values, and likelihood ratios. Data analysis was performed with the statistical package for the social sciences (SPSS) software. The study was approved by the Ethics Committee of Udayana University Medical School/Sanglah Hospital in Denpasar. Subjects were followed until the time of PICU discharge for survivors or death (Figure 1).

## Results

During the study period, 54 children were enrolled, consisting of 33 males and 21 females, with an age

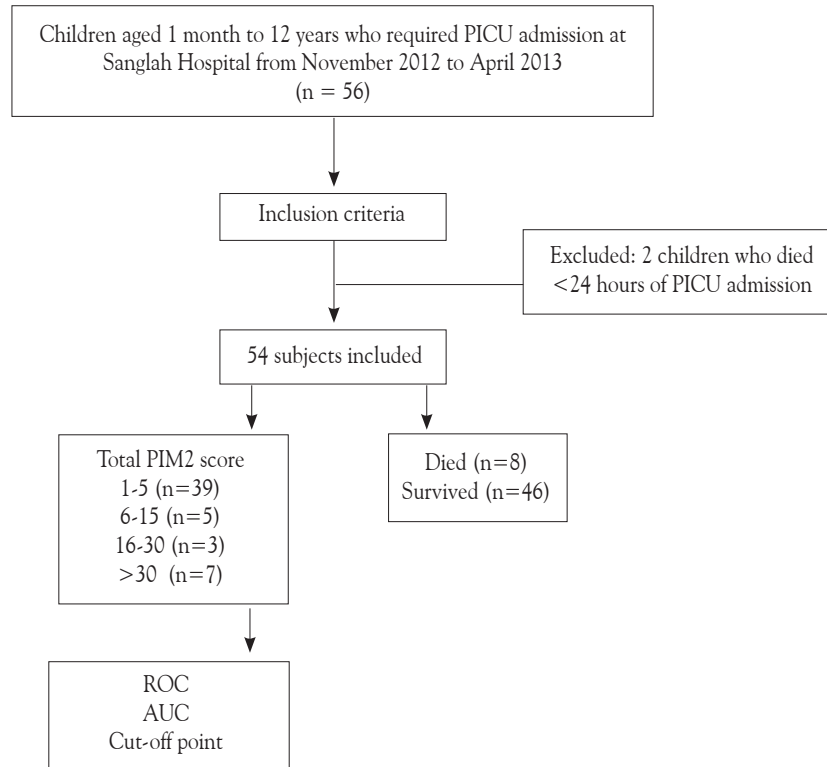


Figure 1. Study scheme

Table 1. Subjects' characteristics

Characteristics	N=54
Gender, n(%)	
Males	33 (6.1)
Age, n(%)	
<2 years	33 (66.7)
2-5 years	6 (11.2)
>5 years	12 (22.2)
High risk diagnosis, n(%)	51 (94.4)
Low risk diagnosis, n(%)	50 (92.6)
PIM parameters	
Mean systolic blood pressure (SD), mmHg	81.8 (27.1)
Pupil diameter, n(%)	47 (87)
Mean FiO2 (SD), %	0.75 (0.3)
Mean PaO2 (SD), mmHg	129.8 (48.9)
Mean base excess (SD)	-4.1 (10.1)
Mechanical ventilation, n(%)	33 (61.1)
Elective admission to PICU, m(%)	54 (100)
Recovery post-surgery/procedure, n(%)	43 (79.6)
Bypass, n(%)	54 (100)
Total PIM 2 score, n(%)	
0-5	39 (72.2)
6-15	5 (9.3)
16-30	3 (9.3)
>30	7 (13.0)
Mortality, n(%)	8 (14.8)

distribution of 1 month to 12 years. The characteristics of subjects are described in Table 1. Most patients were less than 2 years of age (66.7%). Subjects' mean systolic blood pressure was 81.8 (SD 27.1) mmHg. Most subjects had PIM2 total scores  $\leq 5$  (72.2%), followed by scores  $>30$  (13%). Mortality occurred in 8 children (14.8%). The PIM2 discrimination between survival and death is presented on a ROC curve in Figure 2. The c-index was 0.81 (95%CI 0.59 to 1.03).

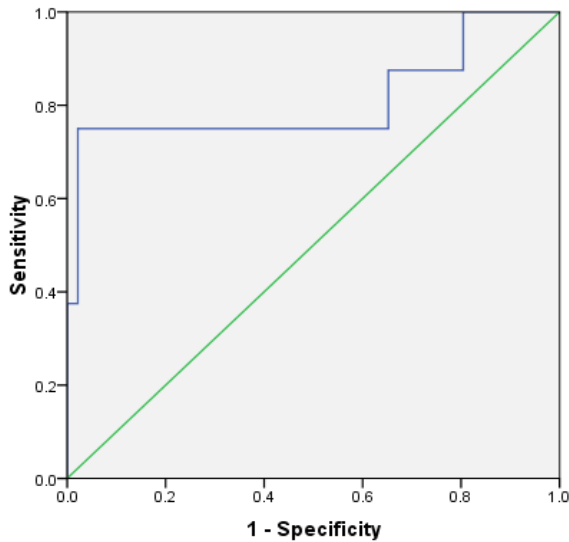
The optimal cut-off PIM2 score value was at a  $\geq$

Table 2. Diagnostic values of the PIM2 score  $\geq -0.99$  cut-off towards mortality

Score PIM2	Mortality		Total
	Yes	No	
$\geq 99$	6	1	7
$< 99$	2	45	47
Total	8	46	54

Specificity 98 (95%CI 87 to 99)%, P = 0.006; sensitivity 75 (95%CI 36 to 96)%, P = 0.006; negative predictive value 96 (95%CI 84 to 99)%; positive predictive value 85 (95%CI 42 to 99)%

-0.99 cut-off, with a sensitivity of 75% and a specificity of 98%. Diagnostic values of the intersection PIM2 score  $\geq$  -0.99 cut-off with specificity, sensitivity, NPV, PPV, and 95%CI are shown in **Table 2**.



**Figure 2.** ROC curve survival vs. death

## Discussion

Our study showed that PIM2 score has a good discriminative ability (c-index 0.81) in differentiating children who would die from those who would survive in PICU. Based on our knowledge, this was the first study to assess the use of the PIM2 in Indonesia. Various studies suggest that the 8-variable PIM model is an appropriate measure to estimate the probability of death of PICU patients.<sup>9</sup> However, the latest version of this index, PIM2, utilizes 10 variables.<sup>3,5</sup> At present, there are two key mortality prediction models for children, namely PRISM and PIM, with the most recent versions called PRISM III and PIM2. The PRISM III was developed in the United States, derived from data collection in 1993-1994.<sup>4</sup> The PIM2 was developed in Australia, New Zealand, and the UK, derived from data collection in 1997-1999.<sup>3</sup> A previous study comparing PRISM III and PIM2 using multicenter data showed similar performance in Australia, New Zealand, and the UK.<sup>5</sup> We explored the PIM2 model rather than PRISM III because it is simple to use, and contains readily

available patient information collected at the time of PICU admission.

Of the 54 subjects in this study, 61.1% were males. Previous studies had results similar to our study.<sup>7,9-11</sup> However, Pedroet *al.* had equal numbers of male and female subjects in their study.<sup>6</sup> Our study involved children aged 1 month to 12 years at the Sanglah Hospital PICU, but most subjects were < 2 years. This young age may have been due to fact that younger children tend to be more susceptible to infections which might result in critically ill conditions. Subjects in a study by Choiet *al.* had characteristics similar to those of our subjects.<sup>12</sup>

Arslankoylu *et al.* showed that the initial PICU treatment affected patient mortality.<sup>9</sup> Pearsonet *al.* recommended the routine use of PIM2 scores to predict mortality of PICU patients in the UK, as PIM2 scores are not affected by the initial PICU therapy. Moreover, it is not difficult to obtain the data necessary to calculate PIM2 scores, which could be calculated with no cost.<sup>14</sup> We found more subjects with lower range in total PIM2 score, so there was a relatively low mortality of subjects treated in our PICU (8 of 54 subjects or 15% mortality rate).

Previous studies have reported on the performance of PIM2 in other countries, including that of Slater *et al.* who calculated an AUC of 0.9 (95%CI 0.89 to 0.92).<sup>3</sup> The PIM2 model showed good/excellent discrimination in the study. Other studies obtained AUC values between 0.8-0.92.<sup>6,7,10,13</sup>

Cut-off values are determined by the intersection of sensitivity and specificity of the ROC curve.<sup>15</sup> A previous study showed that the PIM2 (c-index 0.84) had a better discrimination than PRISM (c-index 0.82).<sup>16</sup> We obtained an AUC of 0.81 (95%CI 0.59-1.03) by ROC curve analysis. We found this tool to have a good discrimination ability, as assessed by the c-index.

A limitation of this study was that our hospital can not provide cardiopulmonary bypass procedures, thus patients requiring cardiopulmonary bypass care were not included in the study. Also, our study was limited to children aged 1 month to 12 years. Further study with a wider age range, involving children aged 12 - 18 years is needed to improve on the application of this study in Indonesian pediatric population.

In conclusion, the PIM2 model is a robust method to predict mortality in PICU patients.

## Conflict of interest

None declared

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