**Pediatric Index of Mortality 3 score as a predictor for the outcomes of critically ill patients**

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**Abstract**

**Background** The ability to predict mortality in critically ill patients is important for assessing patient prognosis, evaluating therapy, and assessing intensive care unit quality. The Pediatric Index of Mortality (PIM) 3 is a scoring system to predict outcomes in order to assist clinical decision-making.

**Objective** To assess the ability of PIM 3 to predict outcomes of critically ill PICU patients.

**Methods** This prospective cohort study included 150 children aged 1 month to 18 years who were admitted to the pediatric intensive care unit (PICU), Sanglah Hospital, Denpasar, Bali. Subjects were grouped into two based on ROC curve PIM score ≥48 and <48. The PIM 3 score was consisted of 10 variables, with a re-diagnosis classification of the PIM 2 score. Bivariate analysis was conducted to both groups to find the distribution of mortality in both groups, followed by homogenity test on variables gender, age, nutritional status, length of stay and mechanical ventilation. Variables which made the cut on bivariate test were included in multivariate analysis.

**Results** The optimal PIM 3 score limit in predicting mortality was ≥48, with area under the curve (AUC) 76% (95%CI 0.69 to 0.85). Multivariate analysis revealed a 2.48 times increased risk to mortality in patients with PIM 3 score ≥48 (95%CI 1.6 to 3.7). In addition, PICU length of stay ≤7 days was a significant risk factor for mortality.

**Conclusion** The PIM 3 has a good ability to predict the outcome of critically ill PICU patients. Critically ill patients with PIM 3 score ≥48 have a higher risk of mortality compared to those with PIM 3 < 48. [Paediatr Indones. 2020;60:328-33; DOI: 10.14238/pi60.6.2020.328-33].

**Keywords:** pediatric index mortality 3 scores; critically ill; prognosis outcomes; pediatric intensive care units

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Critical illness is a life-threatening disturbance in the body’s homeostasis, often comprising any severe problem of the airway, breathing, or circulation, or acute deterioration of the conscious state. The Pediatric Index of Mortality (PIM) 3 is used to predict outcomes of critically ill patients, which helps in clinical decision-making. The PIM 3 system is a scoring system that assesses the risk of mortality in critically ill patients. It is simple, requires less data compared to other tools, and has no licensing fee. The original PIM score was revised into the PIM 3 version, using...
large amounts of data from the Australian and New Zealand Paediatric Intensive Care Registry and the Paediatric Intensive Care Audit Network National Report 2009-2011.

Study on the usefulness of PIM 3 as a predictor of death in critically ill children in the PICU has been limited. As such, we aimed to assess the ability of PIM 3 to predict outcomes of critically ill PICU patients at Sanglah Hospital, Denpasar, Bali.

Methods

This prospective cohort study included children aged 1 month to 18 years who were admitted to the PICU, Sanglah Hospital, Denpasar, Bali, from February to December 2018. Subjects were rated by the PIM 3 within 1 hour of PICU admission. Nutritional status was defined based on Waterlow’s criteria using the following formula: body weight/ideal body weight x 100%. Subject then classified as obese (>120%), overweight (110-120%), well nourished (90-110%), moderate malnutrition (70-90%), and severe malnutrition (<70%).

The PIM 3 components are shown in Table 1. Patients with brain stem death, incomplete data, or death within 1 hour of PICU admission were excluded. Subjects were followed until PICU discharge and evaluated on the outcome of survived vs. died. The PIM 3 score calculation was done with formulation in Figure 1.

The minimum required sample size was calculated to be 150 patients using a formula for unpaired categorical comparative analysis, with beta 80% and alpha 0.05. Data analysis consisted of descriptive statistical analysis, determining the PIM 3 cut-off score by observing the AUC from the receiver operating characteristic (ROC) curve, as well as bivariate and multivariate analysis.

### Table 1. The full outline of unresponsiveness score

| PIM 3 components                                           |
|------------------------------------------------------------|
| 1. Systolic blood pressure (SBP) (mmHg). (cardiac arrest=0, |
| 30=shock/pre-shock, unknown=120)                          |
| 2. Pupillary reactions to bright light (>3 mm and both fixed=1, |
| other or unknown=0)                                        |
| 3. ([FiO2 x 100]/PaO2). PaO2 mmHg, FiO2 at the time of PaO2 |
| if oxygen via endotracheal tube or headbox (FiO2 or PaO2 unknown, |
| ([FiO2 x 100]/PaO2) = 0.23) (unknown = 0)                  |
| 4. Base excess in arterial or capillary blood, mmol/L (unknown =0) |
| 5. Mechanical ventilation at any time during the first hours in ICU (no = 0, yes = 1) |
| 6. Elective admission to ICU (no = 0, yes = 1)               |
| 7. Recovery from surgery or procedure is the main reason for |
| ICU admission                                                 |
| [0] No                                                        |
| [1] Yes, recovery from a bypass cardiac procedure            |
| [2] Yes, recovery from a non-bypass cardiac procedure         |
| [3] Yes, recovery from a non-cardiac procedure                |
| 8. Low-risk diagnosis. Record the number in brackets. If in doubt record 0. |
| [0] None                                                     |
| [1] Asthma is the main reason for ICU admission              |
| [2] Bronchiolitis is the main reason for ICU admission       |
| [3] Croup is the main reason for ICU admission               |
| [4] Obstructive sleep apnea is the main reason for ICU admission |
| [5] Diabetic ketoacidosis is the main reason for ICU admission |
| [6] Seizure disorder is the main reason for ICU admission     |
| 9. High-risk diagnosis. Record the number in brackets. If in doubt record 0. |
| [0] None                                                     |
| [1] Spontaneous cerebral hemorrhage                          |
| [2] Cardiomyopathy or myocarditis                           |
| [3] Hypoplastic left heart syndrome                          |
| [4] Neurodegenerative disorder                              |
| [5] Necrotizing enterocolitis is the main reason for ICU admission |
| 10. Very high-risk diagnosis. Record the number in brackets. If in doubt record 0. |
| [0] None                                                     |
| [1] Cardiac arrest preceding ICU admission                   |
| [2] Severe combined immune deficiency                        |
| [3] Leukemia or lymphoma after first induction               |
| [4] Bone marrow transplant recipient                         |
| [5] Liver failure is the main reason for ICU admission        |

PIM3val = 3.823 x pupils – 0.5378 x elective + 0.9763 x mech. vent. + 0.0671 x absolute BE – 0.0431 x SBP + 0.1716 x (SBP x SBP/1000) + 0.4214 x (100 FiO2/PaO2) – 1.2246 x recov. card. byp. pr. – 0.8762 x recov. non-byp. card. pr. – 1.5164 x recov. non-card. pr. + 1.6225 x VHRdiag + 1.0725 x HRpr – [(2.1766 x LRdiag) – 1.7928].

The mortality risk PIM3 score = ePIM3val / (1 + ePIM3val)

Figure 1. Formulation for PIM 3 score calculation

Notes: mech. vent.=mechanical ventilation, BE= base excess, SBP=systolic blood pressure, recov. card. byp. pr.=recovery from cardiac bypass procedure, recov. non-byp. card. pr.=recovery from non-bypass cardiac procedure, recov. non-card. pr.=recovery from non-cardiac procedure, VHRdiag=very high risk diagnosis, HRpr= high risk procedure, LRdiag=low risk diagnosis.
multivariate analyses. The bivariate analysis to assess the risk of mortality was done by cross-tabulation in the form of risk ratio by Chi-square test. In addition, multivariate analysis was performed to assess the pure effect of PIM score in predicting mortality by logistic regression test. Results with P values <0.05 were considered to be significant.

Data were recorded and analyzed by SPSS 19. This study protocol was approved by the Ethics Committee of the Medical Faculty at Udayana University/Sanglah Hospital Denpasar, Bali.

**Results**

During the study period 150 patients met the inclusion criteria, while 3 patients were excluded due to brain stem death, incomplete data, or death within 1 hour of admission. Characteristics of subjects according to PIM 3 score group are shown in Table 2. Patients with PIM 3 score below the optimal cut-off score (83 subjects) predominated. The PIM 3 score ≥48 group mostly had subjects aged 10-18 years (22.4%), well-nourished nutritional status (43.2%), and used mechanical ventilation support (79.1%). The PIM 3 score <48 group mostly comprised subjects aged 1 month to 2 years (50.6%), and those with moderate malnutrition (50.1%). However, both groups were mostly male, with length of stay ≤7 days. In addition, respiratory problem disease predominated the PIM 3 score ≥48 group, while surgery patients predominated the PIM 3 score <48 group. Subjects with PIM 3 score >48 had 2.48 times higher mortality risk than those in the PIM 3 score <48 group (Table 3).

A homogeneity test revealed that all variables had the same distribution with regards to PIM 3 (Table 4). Bivariate analysis showed that nutritional status, length of stay, and mechanical ventilation were significantly different between the died and survived groups, with P value <0.25 (Table 5). Mechanical ventilation support had a very wide CI so it was excluded from multivariate analysis to avoid multicollinearity effect. Multivariate analysis of PIM 3 score ≥48 and length of stay ≤7 days revealed that both had significantly increased risks of mortality (Table 6).

The optimal PIM 3 score for predicting mortality was ≥48, with AUC value of 76% (95% CI 0.69 to 0.85), as shown in Figure 2.

### Table 2. Characteristics of subjects based on PIM 3 score

| Characteristics                        | PIM 3 score |
|----------------------------------------|-------------|
|                                        | ≥ 48 (n=67) | < 48 (n=83) |
| Age, n (%): 1 month to <2 years        | 28 (41.8)   | 42 (50.6)   |
| 2-10 years                             | 24 (35.8)   | 30 (36.1)   |
| >10-18 years                           | 15 (22.4)   | 11 (13.2)   |
| Gender, n (%): Male                    | 43 (64.2)   | 48 (58)     |
| Female                                 | 24 (35.8)   | 35 (42)     |
| Mechanical ventilation support, n (%)  |             |             |
| Yes                                    | 53 (79.1)   | 36 (43.3)   |
| No                                     | 14 (20.9)   | 47 (56.7)   |
| Nutritional status, n (%): Obese       | 4 (5.9)     | 6 (7.2)     |
| Overweight                             | 2 (2.9)     | 4 (4.8)     |
| Well-nourished                         | 29 (43.2)   | 25 (30.1)   |
| Moderate malnutrition                  | 27 (40.3)   | 42 (50.1)   |
| Severe malnutrition                    | 5 (7.5)     | 6 (7.2)     |
| Length of stay, n (%): ≤7 days         | 48 (71.6)   | 59 (71.1)   |
| >7 days                                 | 19 (29.6)   | 24 (28.9)   |
| Type of disease, n (%): Respiratory    | 21 (31.3)   | 17 (20.8)   |
| Cardiovascular                         | 1 (1.5)     | 16 (19.3)   |
| Neurological                           | 12 (17.9)   | 4 (4.8)     |
| Hematology and oncology                | 9 (13.4)    | 1 (1.2)     |
| Endocrine and metabolic                | 1 (1.5)     | 0 (0)       |
| Gastrointestinal                       | 1 (1.5)     | 0 (0)       |
| Kidney and urinary tract               | 3 (4.5)     | 2 (2.4)     |
| Infections                             | 9 (13.4)    | 7 (8.4)     |
| Surgery                                | 8 (11.9)    | 36 (43.4)   |
| Others                                 | 2 (3)       | 0 (0)       |

### Table 3. Distribution of mortality based on PIM 3 score

| Variables              | Outcomes | RR | 95%CI          | P value |
|------------------------|----------|----|----------------|---------|
| PIM 3 score, n (%)     |          |    |                |         |
| ≥48                    | Died     | 42 (62.7) | 25 (37.3) | 2.478  | 1.639 to 3.745 | <0.001 |
| <48                    | Survived | 21 (25.3) | 62 (74.7) |         |         |         |
**Discussion**

In our study, most children who died in the PICU were ≤5 years of age (40.2%). A previous study also noted that children who died in the PICU were <5 years (77.2%). Young children have less mature immune systems, which increases their mortality risk. Our subjects were predominantly males (64.2%), which was similar to previous studies which reported 59.3% and 66.66% males in the PICU, respectively.

**Table 4.** Homogeneity analysis of PIM 3 score to mortality based on gender, age, nutritional status, length of stay, mechanical ventilation

| Variables                      | RR specific | Homogeneity test |
|--------------------------------|-------------|------------------|
| Gender                         |             |                  |
| Male                           | 2.943       | 0.238            |
| Female                         | 1.896       |                  |
| Age                            |             |                  |
| ≤5 years                       | 2.325       | 0.234            |
| >5 years                       | 2.877       |                  |
| Nutritional status             |             |                  |
| Severe malnutrition            | 3.000       | 1.681            |
| Not severe malnutrition        | 2.419       |                  |
| Length of stay                 |             |                  |
| ≤7 days                        | 2.786       | 2.260            |
| >7 days                        | 1.684       |                  |
| Mechanical ventilation         |             |                  |
| Yes                            | 1.426       | 0.869            |
| No                             | 2.478       |                  |

**Table 5.** Bivariate analysis of mortality outcomes with gender, age, nutritional status, length of stay, and mechanical ventilation support

| Variables                      | Died | Survived | RR   | 95% CI     | P value |
|--------------------------------|------|----------|------|------------|---------|
| Gender, n (%)                  |      |          |      |            |         |
| Male                           | 40   | 51 (56)  | 1.128| 0.76 to 1.67| 0.547a  |
| Female                         | 23   | 36 (61)  |      |            |         |
| Age, n (%)                     |      |          |      |            |         |
| ≤5 years                       | 41   | 61 (59.8)| 0.877| 0.595 to 1.293| 0.514a  |
| >5 years                       | 22   | 26 (54.2)|      |            |         |
| Nutritional status, n (%)      |      |          |      |            |         |
| Severe malnutrition            | 7    | 4 (36.4) | 1.580| 0.967 to 2.579| 0.203b  |
| Not severe malnutrition        | 56   | 83 (59.7)|      |            |         |
| Length of stay, n (%)          |      |          |      |            |         |
| ≤7 days                        | 49   | 58 (54.2)| 1.407| 0.873 to 2.266| 0.137a  |
| >7 days                        | 14   | 29 (67.4)|      |            |         |
| Mechanical ventilation, n (%)  |      |          |      |            |         |
| Yes                            | 62   | 27 (30.3)| 42.49| 6.054 to 298.3| <0.0001a|
| No                             | 1    | 60 (98.6)|      |            |         |

a=Chi-square; b=Fisher’s exact test

**Table 6.** Multivariate analysis of PIM 3 score and length of stay

| Variables                    | RR   | 95% CI     | P value |
|------------------------------|------|------------|---------|
| PIM 3 score ≥48              | 2.867| 1.070 to 7.679| 0.036  |
| Length of stay ≤7 days       | 6.040| 2.194 to 16.627| <0.0001|

**Figure 2.** ROC curve of PIM 3 scores to predict mortality
The majority of our subjects had moderate malnutrition (46%), similar to a previous study which noted that 48.9% of PICU patients had moderate malnutrition. Malnutrition can alter intestinal barrier function, wound healing processes, and muscular function, as well as play a role in disease prognosis. High prevalences of acute and chronic malnutrition have been reported in PICU settings (24%-53%). Malnutrition tends to increase morbidity and mortality, length of stay, duration of ventilator usage, and maintenance costs.

Of 89 subjects (59.3%) requiring mechanical ventilation support, 53 subjects (59.6%) had PIM 3 score ≥48 and 36 subjects (40.4%) had PIM 3 score <48. A study reported that 50.7% of patients received mechanical ventilation. While mechanical ventilation is a life-saving method, it can lead to complications such as barotrauma, ventilator-associated pneumonia, pneumothorax, or ventilator-induced lung injury. Mortality in mechanically-ventilated adult patients was reportedly 58.3%, with 2.67 times higher mortality risk compared to patients without mechanical ventilation.

Length of PICU stay not only reflects the severity of disease and patient health status, but also the quality and capability of the PICU. Longer length of stay increased mortality rate by 10 times. In our study, 49% of those with PIM 3 score ≥48 group had length of stay ≤7 days and 71.6% had length of stay <7 days. Length of stay can be affected by severity of disease, nosocomial infection, as well as refusal of mechanical ventilation or resuscitation while in the PICU.

Diagnosis at the time of PICU admission is important for prognosis. A previous study found that the most common diagnosis at PICU admission was respiratory disease (24.56%), followed by neurological disease (21.05%), cardiovascular disease (15.78%), and infectious disease (14%). The most frequent diagnosis in our subjects was surgery (29.33%), followed by respiratory disease (25.33%), neurological disease (16%), cardiovascular disease (17%), infectious disease (16%), hemat-o-ncological disease (6.67%), other diseases (2%), metabolic endocrine disease (1%), and gastro-hepatological disease (1%). Surgery was predominant because Sanglah Hospital is the largest hospital in Eastern Indonesia. As such, the hospital caseload is largely surgical, hence, we used surgery as a disease classification.

Of the 63 subjects who died, 42 subjects had PIM 3 score ≥48 and 21 subjects had PIM 3 score <48, with RR value of 2.478 (95% CI 1.639 to 3.745; P<0.001). Therefore, the PIM 3 score cut-off of 48 was statistically significant and can be used as a mortality predictor.

Bivariate analysis revealed that nutritional status, length of stay, and mechanical ventilation had significantly different mortality outcomes, with P <0.25. However, mechanical ventilation support had a very wide CI so we included it into multivariate analysis to avoid multi-collinearity effect. Multivariate analysis showed that PIM 3 score ≥48 had a mortality risk of 2.867 times (95% CI 1.970 to 7.679; P=0.036) and length of stay <7 days had a mortality risk of 6.040 times (95% CI 2.194 to 16.627; P<0.0001). In conclusion, critically ill PICU patients with PIM 3 score ≥48 have a 2.48 times higher risk of mortality than those with PIM 3 score <48. Hence, the PIM 3 is a useful tool for predicting mortality in such patients.

Conflict of Interest
None declared.

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