# Validation of the *Pediatric Early Warning Score* to determine patient deterioration from illness

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## Abstract

**Background** Patients who enter the emergency room (ER) present with a variety of conditions, ranging from mild to critical. As such, it may be hard to determine which patients are in need of intensive care unit treatment. *The Pediatric Early Warning Score* (PEWS) has been used to identify signs of critical illness in pediatric patients.

**Objective** To validate the PEWS system for assessing signs of critical illness in pediatric patients at Dr. Mohammad Hoesin Hospital, Palembang.

**Methods** Subjects were children aged 1 month to 18 years who received treatment in the ER and Pediatrics Ward in Dr. Mohammad Hoesin Hospital in March to April 2015. Assessment with PEWS was based on vital sign examinations. Scores ranged from 0 to 9. The PEWS was generally taken twice, first in the ER, then after 6 hours in the ward. We obtained the cut-off point, sensitivity, and specificity of PEWS, in terms of need for pediatric intensive care unit (PICU) treatment.

**Results** One hundred fifty patients were included in this study. Patients with PEW score of 5 or greater in the ER were relatively more likely to be transferred to the PICU, with a sensitivity of 94.4% and a specificity of 82.5%. The cut-off point obtained from the ROC curve was score 4.5 with AUC 96.7% (95%CI 93.4 to 99.9%; P<0.001).

**Conclusion** A PEWS score of cut-off ≥5 may be used to determine which patients are in critically ill condition requiring treatment in PICU. **[Paediatr Indones. 2016;56:251-6. doi: 10.14238/pi56.4.2016.251-6]**.

**Keyword:** *validation; pediatric early warning score; PEWS*

The emergency room is one of the main gateways for health care services aimed at saving patient lives. Patients at risk for deterioration in a hospital setting may not be easily identified. Therefore, it is useful to have a system of emergency assessment which is easy for medical personnel with different levels of experience and training to perform.[1-3] The emergency assessment of children recommended by the *American Academy of Pediatrics* (AAP) is the *Pediatric Assessment Triangle* (PAT),[4] which is used at Dr. Mohammad Hoesin Hospital, Palembang. This system is helpful to assess critical conditions of children in the ER. But the PAT system is difficult for medical personnel with limited pediatric experience to implement.[5] *Pediatric Early Warning Score* (PEWS) was invented at the beginning of 2002. This scoring system is used to recognize the early signs of deterioration of pediatric patients coming through the ER. The PEWS is an objective tool to assess clinical situations and to predict the occurrence of deterioration in pediatric patients treated in pediatric wards.[6-8]

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We aimed to validate the PEWS system at Dr. Mohammad Hoesin Hospital, Palembang for the following reasons; (1) to validate an objective assessment system that can be used to easily identify early signs of emergency in children, especially in areas with limited health facilities; (2) for early detection so that procedures can be done as soon as possible to reduce mortality, morbidity, and complications; and (3) because such study has never been done in Dr. Mohammad Hoesin Hospital.

## Methods

This study was conducted in the ER and Pediatrics Ward Dr. Mohammad Hoesin Hospital, Palembang, from March to April 2015. Subjects were 150 pediatric patients aged 1 month to 18 years who visited the ER and were treated in the pediatrics ward. We excluded pediatric patients who received resuscitation but did not respond, those who did not require inpatient care, or whose parents did not consent to participation.

The PEWS system focuses on three assessment components: consciousness, circulation, and respiratory, with ranged of scores 0 to 9 (**Table 1**). These scores were assessed twice per patient, first, in the ER (PEWS I), then 6 hours later in the ward or PICU (PEWS II).

Positive predictive value of 42.5 % PEWS meant that children with a positive test result or score ≥ 5 has the possibility of having deteriorated condition of 42.5 % . Negative predictive value of 99.1 % PEWS meant that children with negative test results or

scores <5 are possibly not experience deteriorated condition of 99.1%. Youdens index meant the possibility of false negatives and false positives small, because its more than 0.5.

Subjects' parents/guardians provided informed consent. We collected information on patient characteristics, including name, age, sex, address, nutritional status, and disease profiles. The PEWS assessments were made by physicians in the ER (pediatric residents) and ward. Using the receiver operating curve (ROC) analysis, we assessed PEWS score cut-off point that indicated a critical condition requiring PICU treatment. We also obtained sensitivity and specificity results for the PEWS cut-off score.

## Results

In a total of 150 subjects, the male to female ratio was 1.2: 1. **Table 2** shows the general characteristics of the subjects. Subjects' age group distribution was spread fairly evenly, with the most subjects in the 1-5-year age group (44 children; 29.3%). The majority of subjects had good nutritional status (83 children; 55.3%). Most patients arrived from 14:00 to 21:00 pm for treatment in the PICU (78 children; 52%). In addition, most subjects came from the reference city and the majority of ER patients had an underlying infectious disease (49 children; 32.7%). Patients who were treated in the PICU had PEWS I scores ≥ 4. The mode value (largest number of subjects) was a score of 1, consisting of 42 children (28%); and the smallest number of subjects had a score of 8. Four

**Table 1**. Pediatric Early Warning Scoring system[6]

| Components | 3 | 2 | 1 | 0 |
|---|---|---|---|---|
| Consciousness | Lethargic/confused Reduced response to pain | Irritable | Sleeping | Playing Appropriate |
| Cardiovascular | Grey and mottled or capillary refill ≥5 seconds Tachycardia of 30 above normal rate or bradycardia | Grey capillary refill 4 seconds Tachycardia of 20 above normal rate | Pale Capillary refill 3 seconds | Pink Capillary refill 1-2 seconds |
| Respiratory | RR 5 below lower limit of normal with sternal Recession, tracheal tug or grunting 50% $FiO_2$ or 8+ L/min | RR >20 above upper limit of normal Recessing, tracheal tug 40%+ $FiO_2$ or 6+ L/min | RR >10 above upper limit of normal Accessory muscles use 30%+ $FiO_2$ or 4+ L/min | Within normal parameters No recession or tracheal tug |

RR=respiratory rate

children (2.7%) had the maximum PEWS II score of 9, and they were all treated in the PICU.

Respiratory parameters showed no significant differences between patients with rapid breathing (tachypnea) and those with normal breathing. Only a few patients had abnormally slow breathing (bradypnea). Reduced oxygen saturation was seen in 62 children (41.3%). Rapid heart rate was observed in 25 children (16.7%), while 125 children (83.3%) had normal heart rate. Subjects' cardiorespiratory parameters are shown in **Table 3**.

From the receiver operator curve (ROC), the

**Table 2.** General characteristics of subjects (n=150)

| Characteristics | Pediatric ward n (%) | PICU n (%) | Total n (%) |
|---|---|---|---|
| Gender | | | |
|   Male | 74 (49.3) | 9 (6.0) | 83 (55.3) |
|   Female | 58 (38.6) | 9 (6.0) | 67 (44.7) |
| Age group | | | |
|   1 to ≤12 months | 33 (22.0) | 7 (4.7) | 40 (26.7) |
|   >1 to ≤ 5 years | 39 (26.0) | 5 (3.3) | 44 (29.3) |
|   >5 to ≤10 years | 35 (23.3) | 3 (2.0) | 38 (25.3) |
|   >11 to ≤18 years | 3 (2.0) | 3 (2.0) | 28 (18.7) |
| Nutritional status | | | |
|   Good | 74 (49.3) | 3 (2.0) | 83 (55.3) |
|   Malnourished | 34 (22.7) | 4 (2.7) | 38 (25.3) |
|   Severely malnourished | 16 (10.6) | 4 (2.7) | 20 (13.3) |
|   Overweight | 5 (3.0) | 0 (0.0) | 5 (3.3) |
|   Obese | 3 (2.0) | 1 (0.6) | 4 (2.7) |
| Referral source | | | |
|   In the city | 86 (57.3) | 13 (8.7) | 99 (66.0) |
|   Outside the city | 46 (30.6) | 5 (3.3) | 51 (34.0) |
| Distribution hours of arrival to ER | | | |
|   07.00-14.00 | 23 (15.3) | 4 (2.7) | 27 (18.0) |
|   14.01-21.00 | 69 (46.0) | 9 (6.0) | 78 (52.0) |
|   21.01-06.59 | 40 (26.7) | 5 (3.3) | 45 (30.0) |
| Distribution of diseases | | | |
|   Respiratory | 19 (12.7) | 3 (2.0) | 22 (14.7) |
|   Infectious | 46 (30.6) | 3 (2.0) | 49 (32.7) |
|   Neurologic | 15 (10.0) | 8 (5.3) | 23 (15.3) |
|   Gastrohepatologic | 16 (10.7) | 2 (1.3) | 18 (12.0) |
|   Hemato-oncologic | 12 (8.0) | 0 (0.0) | 12 (8.0) |
|   Cardiologic | 9 (6.0) | 1 (0.6) | 10 (6.6) |
|   Nutritional / metabolic | 1 (0.6) | 0 (0.0) | 1 (0.6) |
|   Allergic / immunologic | 3 (2.0) | 0 (0.0) | 3 (2.0) |
|   Nephrologic | 9 (6.0) | 0 (0.0) | 9 (6.0) |
|   Endocrinologic | 2 (1.4) | 1 (0.6) | 3 (2.0) |
| PEWS score | | | |
|   0 | 1 (0.6) | 0 (0.0) | 1 (0.6) |
|   1 | 42 (28.0) | 0 (0.0) | 42 (28.0) |
|   2 | 25 (16.6) | 0 (0.0) | 25 (16.6) |
|   3 | 24 (16.0) | 0 (0.0) | 24 (16.0) |
|   4 | 17 (11.4) | 1 (0.6) | 18 (12.0) |
|   5 | 16 (10.6) | 2 (1.4) | 18 (12.0) |
|   6 | 7 (4.7) | 5 (3.3) | 12 (8.0) |
|   7 | 0 (0.0) | 5 (5.5) | 5 (3.0) |
|   8 | 0 (0.0) | 1 (0.6) | 1 (0.6) |
|   9 | 0 (0.0) | 4 (2.7) | 4 (2.7) |

area under the curve (AUC) was 96.7% (95%CI 93.4 to 99.9%; P<0.001), and the PEWS I cut-off score was 4.5, with a sensitivity of 94.4% and a specificity of 82.6%. For PEWS I with a total score of 4, 5, or 6, we obtained the best sensitivity and specificity

the PICU. In contrast, a previous study found that 55.3% of subjects were treated in the pediatrics ward and 32.9% needed PICU treatment.[6] The most common diseases suffered by our subjects treated in the ER were infection (32.7%), followed by neurologic

**Table 3**. Cardiorespiratory parameters of pediatric patients in the emergency room (n=150)

| Parameters \ Age groups | 1-12 months | >1 to ≤5 years | >5 to ≤10 years | >10 to ≤18 years | Total | % |
|---|---|---|---|---|---|---|
| Respiration, n | | | | | | |
|   Normal | 14 | 22 | 24 | 16 | 76 | 50.6 |
|   Tachypnea | 23 | 20 | 12 | 12 | 67 | 44.6 |
|   Bradypnea | 3 | 2 | 2 | 0 | 7 | 4.8 |
| Mean respiratory rate (SD), x/min | 51.4 (20.) | 38.2 (14.1) | 29.4 (7.8) | 29.4 (8.1) | | |
| Heart rate, n | | | | | | |
|   Normal | 35 | 36 | 33 | 21 | 125 | 83.3 |
|   Tachycardia | 5 | 8 | 5 | 7 | 25 | 16.7 |
|   Bradycardia | 0 | 0 | 0 | 0 | 0 | 0 |
| Mean heart rate (SD), x/min | 142.4 (24.4) | 129.5 (22.2) | 107.3 (20.4) | 110.1 (2.3) | | |
| Oxygen saturation, n | | | | | | |
|   97-100% | 17 | 24 | 25 | 22 | 88 | 58.6 |
|   94-96% | 9 | 10 | 7 | 5 | 31 | 20.6 |
|   90-93% | 5 | 3 | 2 | 0 | 10 | 6.8 |
|   <90% | 9 | 7 | 4 | 1 | 21 | 14.0 |
| Median oxygen saturation (range), % | 95 (70-99) | 98 (80-99) | 98 (68-99) | 98 (65-99) | | |

**Table 4.** Changes in PEWS I to II scores in pediatric ward patients (n = 40)

| PEWS I score | PEWS II score | n | Transferred to PICU | Underlying disease |
|---|---|---|---|---|
| Score 4 (n=17) | 1 | 1 | - | |
| | 2 | 1 | - | |
| | 3 | 7 | - | |
| | 4 | 6 | - | |
| | 6 | 1 | + | Respiratory |
| | 7 | 1 | + | Respiratory |
| Score 5 (n=16) | 2 | 2 | - | |
| | 3 | 1 | - | |
| | 4 | 3 | - | |
| | 5 | 9 | - | |
| | 9 | 1 | + | Neurologic |
| Score 6 (n=7) | 3 | 2 | - | |
| | 4 | 1 | - | |
| | 6 | 3 | - | |
| | 7 | 1 | + | Respiratory |

for PEWS score ≥ 5, which were 94.4% and 82.5%, respectively (**Table 4**).

## Discussion

Of 150 subjects, 88% were treated in the general pediatrics ward and 12% were directly treated in

and respiratory. Wahyudi *et al.* noted that 42.4% of ER patients had infectious diseases.[9] The majority underlying disease or indication for our PICU patients were neurological and respiratory distress, or threatening respiratory failure. After 6 hours of treatment in the ward, some patients experienced changes from the PEWS I to PEWS II scores. Some children with PEWS I scores of 4, 5, or 6 had reduced

PEWS II scores following 6 hours of treatment in the ward. However, 4 patients had escalated PEWS II scores, so they were transferred to the PICU.

Respiratory distress or failure is the primary diagnosis in nearly 50% of children admitted to the PICU, and is a common cause of cardiopulmonary arrest in children. There is substantial variability in the etiology and severity of the illness.[10-12] Likewise, we found that respiratory distress or failure was the most common cause of pediatric transfers to the PICU.

The PEWS constitutes a platform for objective evaluation of a child's condition by allowing the conversion of routine observations into an actionable index that provides the basis for further evaluation. By providing a foundation for objective (quantitative/numerical) assessment of a patient's condition, these systems can potentially improve communication between health care professionals, thus preventing misunderstanding and misinterpretation. Providing nurses and physicians with a tool for reaching a common understanding to establish deviations from normal parameters can be potentially advantageous.[13]

The cut-off PEWS score obtained from the subjects was 4.5, with an AUC obtained from the ROC of 96.7% (95%CI 93.4 to 99.9%; P <0.001), sensitivity of 94.4%, and specificity of 82.6%. Monaghan and Akre also found that a scores ≥ 4 were critical values that required immediate action. The Monaghan study found that 80% of patients with score ≥ 4 could accurately assess patient deterioration that required immediate action, but they did not report sensitivity and specificity.[6,7,15]

A study applied a further modified version of the Brighton PEWS and showed that the mean (SD) maximum (highest) PEWS in patients admitted to the PICU was 2.95 (1.5). The sensitivity and specificity of a PEWS of 2.5, for transfer to a higher level of care, were 62% and 89%, respectively.[14] In our study, the best sensitivity and specificity were seen with PEWS score ≥ 5, with 94.6% and 82.5%, respectively. The PEWS score ≥5 also had a positive predictive value of 42.5% and negative predictive value of 99.1%, with Youden's index of 0.77. In contrast, Skaletzky *et al*. reported that patients with PEWS score of 2.5 were not directly transferred to the PICU, but were monitored for 48 hours. Patients whose conditions deteriorated received more intervention or were transferred to the PICU.[14] But, in our study, our patients were not followed up for the subsequent 48 hours.

A limitation of this study was the subjectivity of the assessors. Although we used objective tools, such as patient monitors and pulse oxymetry for oxygen saturation, the assessors measured heart and respiratory rates for one minute by a stopwatch. As such, an inter-rater analysis for reliability should have been carried out to compare the assessors' agreement for the same patient.

In conclusion, the PEWS scoring system can be used to assess the emergency signs in pediatric patients with good sensitivity and specificity. A total PEWS score of 5 is the optimum cut off for patients admitted to PICU Dr. Mohammad Hoesin Hospital, Palembang, Indonesia.

## Conflict of interest

None declared.

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