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Inaccurate Recording of Pediatric Early Warning Score Associated with Clinical Outcomes: An Experience from a Developing Country

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Abstract

BACKGROUND: The pediatric early warning score (PEWS) can assist in the identification of patients on wards who are at risk of deterioration.

AIM: This study was aimed to examine the accuracy of PEWS recording and its association with clinical outcomes in a tertiary hospital.

METHODS: A retrospective and case-controlled study was conducted on participants aged 1 month – 18 years admitted emergently from the ward to the pediatric intensive care unit (PICU) due to clinical deterioration between January and December 2021. The documented PEWS score was obtained from medical records, while the corrected PEWS score was calculated from the patients' clinical data at the same time the documented PEWS score recorded.

RESULTS: Total 70 patients who met the inclusion criteria were included for analysis. We observed about 38 patients (54.3%) had PEWS errors. We also observed significant difference in the respiratory and gastroenterology diagnosis categories between the PEWS error group and non-PEWS error group. The mean documented PEWS score at PICU admission was lower in PEWS error patients compared to non-PEWS error patients (1.34 ± 1.28 versus 4.31 ± 2.73, respectively, $p < 0.05$). The need for vasoactive drugs was significantly higher at 72 h after PICU admission and at PICU discharge for the patients in PEWS errors group ($p < 0.05$). PEWS errors group were associated with higher need for vasoactive drugs (RR = 2.01; 95% CI: 1.22–3.31; $p < 0.05$).

CONCLUSION: Inaccurate recording of PEWS caused earlier and higher need for vasoactive drugs in patients with unplanned PICU admission. We highlighted the importance of PEWS in the clinical outcome of pediatric patients.

Introduction

Recognizing deterioration is one of the six core elements of the safe clinical care system implemented by children's hospitals [1]. Moreover, identification of a pediatric patient in need of critical care as soon as possible can improve clinical outcomes and overall mortality [2]. On the other hand, unrecognized clinical deterioration, leading to unplanned pediatric intensive care unit (PICU) transfer, can have tragic consequences for children [3]. Studies revealed in-ward pediatric patients who require unplanned PICU admission increased risk by 13-fold of in-hospital mortality, morbidity, and lengths of stay in the PICU [4], [5]. This highlights the importance of a scoring system to identify pediatric patients who require immediate critical care.

An early warning system is able to help in the improvement of communication between nursing staff and physicians [6]. The first pediatric early warning score (PEWS) system was introduced in 2005 by interviewing healthcare staffs, reviewing adult early warning scores, and conducting research on hospitalized children [7]. Furthermore, a prospective observational study found that PEWS has been proven to be able to identify patients who require immediate transfer to the PICU, reduce the incidences of code blue, improve the quality of communication between staffs, and support patient safety [8]. Taken together, PEWS plays an important role in the management of pediatric patients in hospitals.

Despite the widespread use of PEWS, implementation and standardization have been inconsistent [9], [10]. In a retrospective study, 85.5% of the children with a rapid response team, leading to an unplanned PICU transfer, had a critical PEWS score recorded in many h (median 11 h, 36 min) before the event of interest [11], [12], [13]. Moreover, children likely deteriorate for many different reasons, and a single tool is unlikely to predict all events equally [14]. Although its utility in initiating rapid response team interventions, the PEWS system has not been shown to reduce hospital mortality [15].

A study found that there was a potential for PEWS errors that resulted in the PEWS color changing in 8.8% of patients who were subsequently admitted emergently to the PICU [13]. In addition, there is an evidence that majority of errors cause PEWS documented by medical staffs to score lower than corrected PEWS [16]. Accordingly, errors in PEWS recording could have an impact on outcomes.

Evidence has emerged in the effect of PEWS errors in the patient's outcome. However, the relationship between PEWS errors and outcomes in the PICU has not been established. This study aimed to examine the completeness and accuracy of paper-based charting of PEWS recording in children in tertiary children's hospital in developing country. Furthermore, we examined the association of PEWS errors on length of stay, mortality, need for mechanical ventilation support, and need for vasoactive drugs in patients with unplanned admission to the PICU.

Methods

Patients and study design

We performed an observational retrospective and case-controlled study in pediatric ward tertiary hospital of patients requiring unplanned PICU admission between January and December 2021. The study was conducted at one of Indonesia's main university-based tertiary hospitals, which is equipped with a tertiary-care PICU facility. We received pediatric patients from our region's primary and secondary hospitals.

All patients aged 1 month – 18 years admitted to the PICU and had at least once documented PEWS or vital signs measurement and clinical condition related to PEWS data by nurses were eligible for inclusion. Patients who were admitted from the emergency unit, intensive care unit (ICU), intensive cardiac care unit (ICCU), or neonatal intensive care unit (NICU) were included in this study. Patients who were previously admitted to the COVID-19 intensive care or admitted to PICU to undergo medical procedures were not included in the study. This study was approved by the Medical and Health Research Ethics Committee of the Faculty of Medicine, Public Health and Nursing, Universitas Gadjah Mada, Yogyakarta, Indonesia: KE/FK/1179/EC/2020.

Data collection

We recorded age, gender, source of hospital admission to ward (emergency and non-emergency), diagnosis categories (cardiac, gastroenterology, neurological, renal respiratory, hemato-oncology, and others), time of hospital admission, time of PICU admission, time of hospital discharge, time of PICU discharge, reason of PICU admission (neurological problem, shock, respiratory distress, respiratory failure, and cardiorespiratory failure), and PEWS score.

We defined age as the patient's age when being hospitalized at the ward. Gender was divided into male and female. Unplanned PICU admission was defined as all patients unexpectedly admitted to the PICU from a lower level of care in the hospital [17]. The ward medical team can request a PICU evaluation and/or transfer regardless of the PEWS result. The need for PICU transfer was assessed jointly by the PICU team and ward team based on clinical judgment and was independent of the PEWS score.

Documented PEWS was obtained from the version of the Brighton PEWS translated and adapted for the Indonesian context, which had been implemented as part of routine care since November 2017 [7]. Corrected PEWS was calculated from the patients' clinical data at the same time that the documented PEWS was recorded by the researchers and validated by two external assessors. The two external assessors were blinded to each other's interpretation, and if any disagreement, the results were finalized based on the interpretation of the more experienced intensivist. We defined PEWS errors as any difference between documented and corrected PEWS resulting in PEWS color code change. The error was defined by the creitria including: incorrect chart for child's age, incorrect subscore, incorrect total score, combination, clinically significant, and clinically not significant [12].

Outcome measures

The follow-up period finished when each patient was discharged from the hospital, which was considered either as survived or died. The outcomes were mortality, need for mechanical ventilation support, need for vasoactive drugs, length of PICU stay, and length of hospital stay at 72 h after PICU admission and at PICU discharge.

Data analysis

Statistical analysis was performed using SPSS version 25 for Windows (IBM Corp., Armonk, NY) with a significance threshold of <0.05 in two-sided tests. Continuous variables were expressed as mean ± standard deviation (SD), or median (Q1, Q3), and categorical variables as number (percentage). Group comparisons were performed using the Fisher's exact test for categorical variables and Mann–Whitney test for continuous variables. The association between PEWS errors status and outcomes was assessed using the Chi-square test to determine relative risk (RR) with 95% confidence interval (CI) and significance set as $p < 0.05$. Kaplan–Meier survival analysis was used to compare groups.

Results

Characteristics of study subjects

The baseline characteristics of the 70 patients included in the final analysis are presented in Table 1. Among patients, 38 patients (54.3%) were classified into the PEWS error group and 32 patients (45.7%) were classified into the non-PEWS error group. We observed significant difference in the respiratory and gastroenterology diagnosis categories between the PEWS error group and non-PEWS error group ($p < 0.05$). We observed that the mean documented PEWS score at PICU admission was lower in PEWS error patients compared to non-PEWS error patients (1.34 ± 1.28 versus 4.31 ± 2.73, respectively; $p < 0.05$). We observed significant difference in PEWS components (neurology, cardiovascular, and respiratory) between two groups ($p < 0.05$). In addition, we did not observed significant differences in age, gender, source of hospital admission, day from hospitalization to PICU admission, and reason of PICU admission ($p > 0.05$). We did not observe significant difference after the correction of PEWS scores between two groups (5.05 ± 1.63 versus 4.75 ± 2.84, respectively, $p > 0.05$).

Associations of PEWS with clinical outcomes in patients admitted to PICU

Associations of PEWS with clinical outcomes in patients admitted to PICU are shown in Table 2. We observed that patients in the PEWS error group associated with higher need for vasoactive drugs at 72 h after PICU admission. Next, we observed that patients in the PEWS errors group associated with higher need for vasoactive drugs at PICU discharge. However, we did not observe significant association between PEWS and the length of PICU stay, length of hospital stay, mortality, and need for mechanical ventilation support ($p>0.05$).

Table 2: Associations of PEWS with clinical outcomes in patients admitted to PICU

Outcomes	PEWS error n = 38	Non-PEWS error n = 32	p-value
Length of stay, days (median [IQR])			
PICU	4.79 (7.25)	4.09 (7.87)	0.468
In hospital	20 (21)	17,5 (16)	0.991
Mortality, n (%)			
At 72 h PICU admission	10 (26.3)	8 (25)	0.561
At PICU discharge	21 (55.3)	15 (46.9)	0.323
Need for PICU intervention, n (%)			
Mechanical ventilation support			
At 72 h PICU admission	21 (55.3)	16 (50.0)	0.421
At PICU discharge	24 (63.2)	17 (53.1)	0.272
Vasoactive drugs			
At 72 h PICU admission	19 (50.0)	8 (25.0)	0.048
At PICU discharge	24 (63.2)	10 (31.2)	0.013

IQR: Interquartile range; PICU: Pediatric intensive care unit; PEWS: Pediatric early warning score.

Associations of PEWS error with the risk of clinical outcomes in patients admitted to PICU

Associations of PEWS error with the risk of clinical outcomes in patients admitted to PICU are shown in Table 3. We observed that patients in the PEWS error group associated with an increased the RR of vasoactive drugs needs at 72 h after PICU admission by 1.50-fold (95% CI:1.03-2.18; $p < 0.05$). We observed that patients in the PEWS errors group associated with an increased the RR of vasoactive drugs needs at PICU discharge by 2.01-fold (95% CI: 1.22 – 3.31; $p < 0.05$). We observed that patients in the PEWS errors group were not associated with increased risk of mortality and need for mechanical ventilation support ($p > 0.05$)

Table 1: Characteristics of study subjects

Variable	All (n = 70)	PEWS error (n = 38)	Non-PEWS error (n = 32)	p-value
Age, median (IQR)	6.57 (10.34)	7.26 (11.18)	5.72 (8.45)	0.419
Male, n (%)	36 (51.4)	18 (47.4)	18 (56.2)	0.482
Source of hospital admission n (%)				
Emergency	44 (62.9)	22 (57.9)	22 (68.8)	0.458
Non-emergency	26 (37.1)	16 (42.1)	10 (31.2)	
Diagnosis categories, n (%)				
Cardiac	7 (10.0)	6 (15.8)	1 (3.1)	0.084
Gastroenterology	7 (10.0)	1 (2.6)	6 (18.8)	0.042
Neurological	10 (14.3)	6 (15.8)	4 (12.5)	0.745
Renal	7 (10.0)	4 (10.5)	3 (9.4)	1.000
Respiratory	13 (18.6)	3 (7.9)	10 (31.2)	0.016
Hemato-oncology	16 (22.9)	11 (28.9)	5 (15.6)	0.256
Other	5 (7.1)	4 (10.5)	1 (3.1)	0.366
Day from hospitalization to PICU admission, median (IQR)	6.5 (1.5)	6.5 (1.7)	6.5 (1.5)	0.501
Reason of PICU admission, n (%)				
Neurological problem	7 (10)	3 (7.9)	4 (12.5)	0.695
Shock	16 (22.9)	11 (28.9)	5 (15.6)	0.256
Respiratory distress	23 (32.9)	13 (34.2)	10 (31.2)	1.000
Respiratory failure	16 (22.9)	7 (18.4)	9 (28.1)	0.399
Cardiorespiratory failure	8 (11.4)	4 (10.5)	4 (12.5)	1.000
Documented PEWS score, mean (SD)				
Neurology	0.67 (0.99)	0,26 (0.45)	1.16 (1.22)	0.001
Cardiovascular	0.94 (1.08)	0,55 (0.76)	1.41 (1.21)	0.002
Respiratory	1.09 (1.13)	0,53 (0.73)	1.75 (1.16)	<0.001
Total score	2.7 (2.54)	1,34 (1.28)	4.31 (2.73)	<0.001
Corrected PEWS score, mean (SD)				
Neurology	1.01 (1.14)	0.89 (1.06)	1.16 (1.22)	0.404
Cardiovascular	1.96 (1.15)	2.18 (1.01)	1.69 (1.26)	0.116
Respiratory	1.94 (1.03)	1.97 (0.94)	1.91 (1.15)	0.995
Total score	4.91 (2.25)	5.05 (1.63)	4.75 (2.84)	0.835

IQR: Interquartile range; PICU: Pediatric intensive care unit; PEWS: Pediatric early warning score.

Table 3: Associations of PEWS error with the risk of clinical outcomes in patients admitted to PICU

Outcomes	RR	95% CI
Mortality		
At 72 h PICU admission	1.018	0.772–1.341
At PICU discharge	1.188	0.734–1.920
Need for PICU intervention		
Mechanical ventilation support		
At 72 h PICU admission	1.118	0.681–1.833
At PICU discharge	1.272	0.730–2.219
Vasoactive drugs		
At 72 h PICU admission	1.500	1.030–2.184
At PICU discharge	2.010	1.220–3.310

RR: Relative risk; CI: Confidence interval; PICU: Pediatric intensive care unit; PEWS: Pediatric early warning score.

Estimation of the need of vasoactive drugs in PEWS error

Estimation of the need of vasoactive drugs in patients with PEWS error in patients admitted to PICU is shown in Figure 1. We observed that patients with PEWS error significantly associated with higher and earlier vasoactive drugs at 72 h after PICU admission. We observed that about 50% patients with PEWS errors did not require vasoactive drugs at 72 h after PICU admission. In addition, we observed that about 75% patients without PEWS errors did not require vasoactive drugs at 72 h after PICU admission.

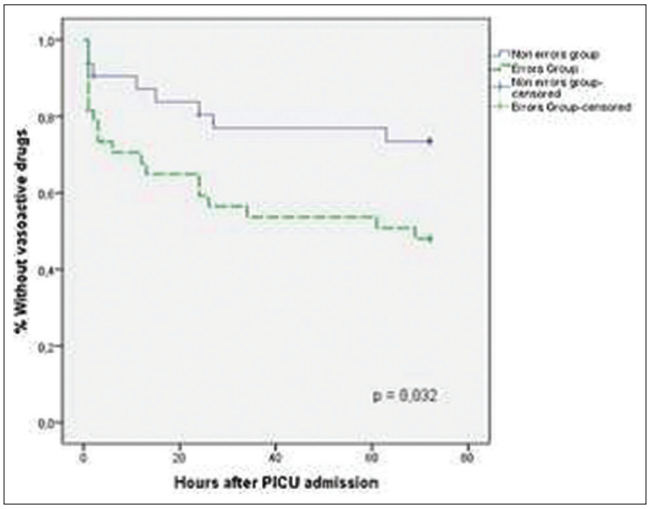

Figure 1. Kaplan-Meier curve of need for vasoactive drugs after PICU admission.

Discussion

The novelty of this study is that we investigated the implementation of PEWS in pediatric outcomes. We further investigated that the significant findings of this work are that the need of vasoactive drugs different from patients with PEWS errors and those without. Our results suggest that PEWS scoring is important factor for the outcome of pediatric patients admitted to PICU.

We observed that the PEWS errors that occurred in our hospital were higher than other studies. A previous study conducted at a pediatric cancer hospital in 2017 showed that errors in calculating the PEWS score resulted in PEWS color code change in 8.8% of patients in the ward requiring unplanned PICU transfer and in 2.2% patients who did not [16]. Moreover, a study showed that about 9% of patients with an incorrect PEWS score resulted in color coded interpretation errors that caused a delay in escalation of monitoring of patients with deterioration in the ward [12]. Meanwhile, a retrospective cohort study in the United States for 8 years revealed that PEWS errors occurred in 5.87% patients per year in the 24 h before unplanned admission to the intensive care unit [13]. We observed that the mean documented PEWS score at PICU admission was lower in PEWS error patients compared to non-PEWS error patients. Incomplete observation sets may exacerbate the risk of underscoring errors. If missing vital sign values are “abnormal” (resulting in a positive subscore), the PEWS may be falsely low because the missing component did not contribute to the overall score. We observed significant difference in PEWS components (neurology, cardiovascular, and respiratory) between two groups ($p < 0.05$). A study highlighted that incomplete observation sets were more likely to contain observations that should have triggered an alert than complete observation sets [18]. Taken together, accurate recording of PEWS is important in patient’s observations.

Next, we further observed that approximately 95% of patients in the PEWS errors group were in relatively safe clinical condition. Highlighting the need of more careful monitoring of PEWS in pediatric patients in the ward who were starting to show clinical deterioration. PEWS was done on all pediatric patients who were treated in the ward; therefore, nurses would have applied PEWS to patients who are relatively safe very often, and eventually, the PEWS only became a routine procedure [19]. In addition, in developing country, low nurse to patient ratios and high workload have been associated with an increase in “missed nursing care,” including vital sign monitoring [20], [21]. In fact, various studies have concluded that the PEWS score could predict the incidence of unplanned admissions to the intensive care unit [8], [22], [23]. Some research revealed that the PEWS system was very accurate for predicting the decline in the clinical condition of patients in hospital with low resources (AUROC 0.94) and also high medical resources (AUROC 0.95) [16], [24]. Accordingly, the implementation of PEWS correctly PEWS can predict clinical conditions.

The optimal cutoff of PEWS scores for predicting the incidence of unplanned admission to the PICU had not been established. In this study, the mean of PEWS total scores in the non-PEWS error group was 4-5. However, in the PEWS error group, the mean was 1-2. Compared to other studies, a study in 2005 used a total score of 4 or the presence of a score of 3 on one of the PEWS components reflected a critical value that required consultation and early intervention [7]. Consistently, a previous study found that the cutoff point of 3 had optimal sensitivity and specificity in predicting unplanned intensive care transfer [8]. A previous research and colleagues demonstrated that the optimal

cutoff point for PEWS was at a score of 4.5 (sensitivity 94.4% and specificity 82.6%) [25]. Another study also stated that PEWS score of 3 was associated with the need for fluid resuscitation, intravenous antibiotics, and oxygen supplementation [26]. This highlights that PEWS could predicting patient's condition.

In this study, we observed that patients with PEWS errors required earlier and more vasoactive drugs than patients without PEWS errors. By the time unplanned admission to the PICU decision had to be made, most of the patients with PEWS errors had fallen into a critical condition that required intervention in the PICU, especially the administration of vasoactive drugs [27]. A study showed a higher PEWS score increased the need for mechanical ventilation support and the need for vasoactive drugs during unplanned PICU admission, with each one-point increase in PEWS score leading to a 1.2-1.5-fold increase in the likelihood of intervention in the PICU [16]. Although there was an increased need for vasoactive drugs in patients with PEWS errors, it did not result in significant increase in mortality and length of stay at the end of PICU admission. This finding could be due to the fact that the favorable outcomes in the PICU were influenced by multiple factors, such as severity of the disease, medical resources available at the time of admission to the PICU, and the clinical condition of the patient at the start of PICU care [28]. Together, inaccurate PEWS recording could affect clinical outcomes of patients.

This study has several limitations. The data used for analysis were based on single tertiary hospital that may not represent patients in other centers. This study did not evaluate the severity of the disease (i.e., pediatric index of mortality or pediatric risk of mortality score) before transfer to the PICU. The possibility of varying decision-making from different intensive care specialists could affect the evaluation results.

Conclusion

Pediatric patients with unplanned admission to PICU with PEWS errors calculation were associated with earlier and higher need for vasoactive drugs. We highlighted the importance of PEWS in the clinical outcome of pediatric patients. It should be noted that training and understanding of scoring system could improve the outcomes of pediatric patients admitted to PICU.

Authors' Contributions

DDR, FM, TW, and DR contributed to the completion of interpretation of the data and the manuscript. DDR, FM, and DR contributed substantially to the concept, design, interpretation of the data, and completion of the study and manuscript. IFK and N contributed to critical revision of the manuscript for important intellectual content. All authors have read and approved the final manuscript.

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