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ORIGINAL ARTICLE

Use of an early warning scoring system in the pediatric ward of a tertiary referral hospital

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Clinical Deterioration, Early Warning Score, Pediatrics.

Abstract

Objective: To evaluate the performance the Brighton Pediatric Early Warning Score for an early identification of clinical deterioration in children admitted to the pediatric ward of a tertiary hospital. **Methods:** A prospective cohort observational study, involving 325 children with acute illnesses admitted to a pediatric ward, aged 29 days to 13 years, between August 2018 and March 2020. To assess the Brighton Pediatric Early Warning Score diagnostic accuracy, it was used the Cardiff and Vale Pediatric Early Warning System as reference, and the software used was the R Core Team 2020. The effectiveness of the Brighton Pediatric Early Warning Score was assessed using the indicators of sensitivity, specificity, positive predictive value, negative predictive value, area under the ROC curve, number of true positives and negatives and false positives and negatives. **Results:** The Brighton Pediatric Early Warning Score showed a sensitivity of 19.2%, a specificity of 99.1%, a positive predictive value of 90.5%, a negative predictive value of 73.7%, and an area under the ROC curve of 0.839. In addition to that, for scores larger than 3, there were 19 true positives, 224 true negatives, 2 false positives and 80 false negatives. **Conclusion:** The Brighton Pediatric Early Warning Score performed well in the scenario analysis chosen by this research, showing how easy it is to use it for an early recognition of clinical deterioration in children admitted to pediatric wards.

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INTRODUCTION

In a hospital setting, patient assessment based on the monitoring of their general status and vital signs is a routine practice. Altered monitoring findings may indicate clinical worsening. Worsening of clinical conditions may prolong hospital stay and increase treatment costs and the risk of morbidity and mortality[1].

Clinical worsening of hospitalized patients is often preceded by alterations within 24 hours before death. However, the care and treatment of critically ill children is particularly challenging. The symptoms of critical illness in this age group may be uncharacteristic, since children have better compensatory mechanisms than adults. In addition, centers overloaded with a high demand for care may cause signs of worsening to go unnoticed. In this context, a child with sepsis or severe dehydration, for example, may not have their signs and symptoms correctly interpreted, which leads, almost immediately, to clinical worsening when compensatory capacity is exceeded[1,2].

According to Rubin et al.[3], approximately 1-3% of children admitted to a hospital are referred to a pediatric intensive care unit (PICU) due to clinical worsening. Although many guidelines for early warning systems (EWS) have been proposed to address this problem, most of these systems focus on the adult population, offering less attention to pediatric patients, who have different vital sign parameters[3].

For example, the first EWS, published in the UK by Morgan et al in 1997, consisted of a simple and easy-to-use instrument for basic clinical and physiological observation, to which weighted values were assigned according to the degree of deviation from normality. Action was initiated from a threshold score, which advised the team to seek specialized support for patients undergoing clinical worsening[1,4].

In this sense, based on existing EWS, several pediatric scoring systems were published in international databases, and later modified and validated in countries such as England, Canada, United States and Australia, with the objective of helping to recognize patients in critical condition and initiate protocols to prevent cardiorespiratory arrest (CRA)[1,5]. Few Brazilian articles have looked into the use of these scoring systems in pediatric patients. One of the best known pediatric early warning score systems (PEWS) is the Brighton Pediatric Early Warning Score (BPEWS) or Monaghan PEWS, the first scale intended for use in children, published in 2005 by a nurse from the University of Brighton, England. This tool helps care teams to identify patients at risk of severe complications through periodic observation of clinical signs and predetermined criteria that define the need for urgent care[6].

Furthermore, PEWS also identify patients undergoing clinical worsening at least one hour before the definitive installation of a state of deterioration. This should allow enough time to initiate accurate management and arrange patient transfer to an intensive care unit[7].

Pediatric early warning scoring systems are of great importance in the early recognition of clinical worsening of patients in an age group that requires special care and attention. This study was carried out in the pediatric ward of a tertiary hospital and included 325 patients. It evaluated the efficacy and applicability of the BPEWS in the Brazilian context.

METHODS

This observational cohort prospective study was conducted in the pediatric ward of a tertiary referral hospital and included children with acute illness aged 29 days to 12 years admitted in the period from August 2018 to March 2020.

A total of 27 children on palliative care, with congenital heart disease, in isolation, or with cancer were excluded.

The study population comprised 325 patients assessed based on the BPEWS / Monaghan PEWS. The number of patients assessed for each parameter varied based on the data available on their medical charts. The parents or guardians of the included patients gave informed consent to their participation in the study. The Tiradentes University Research Ethics Committee approved the study under opinion report no. 2.978.040 and certificate no. 89732718.6.0000.5371.

STATISTICAL ANALYSIS

Categorical variables were described as absolute and relative percentage frequencies, and continuous variables were described as medians and interquartile ranges. The associations between categorical variables were tested using Pearson's chi-squared test with Monte Carlo simulations. The adherence of continuous variables to a normal distribution was tested using the Shapiro-Wilks test; variables not following a normal distribution had their differences in medians tested using the Kruskal-Wallis test. For multiple comparisons, the Z test with Bonferroni correction for categorical variables and the Mann-Whitney test with Dunn correction were applied. The CARDIFF scale [8] was used as a reference in the assessment of the diagnostic accuracy of the BPEWS, where the occurrence of at least one abnormal event according to the first scale was considered an event of interest. Sensitivity, specificity, positive predictive value, negative predictive value, area

under the ROC curve, number of true positives and negatives, and false positives and negatives were calculated. The significance level adopted was 5% and the software used was R Core Team 2020.

RESULTS

The median age of patients was three years (IQR 1-7), with a slight predominance of males (58.5%) over females (41.5%). Most of them lived in Aracaju, the State Capital of Sergipe (53.5%). The mean hospital stay length was seven days (IQR 4-11.5) (Table 1). Two hundred and twenty patients (67.7%) were for hospitalized for reasons that did not require surgery, while 105 (32.3%) needed surgery. Most were hospitalized for respiratory tract diseases (Graph 1).

In terms of the scores under the BPEWS, 60.3% of the patients had a score of 0; 33.3% had scores from 1 to 3; and 6.2% had scores > 3. One hundred and ninety-four patients (99%) in the first group, 104 in the second (96.3%), and 16 in the third (80%) were discharged. The analysis of referrals to other hospitals or to intense care sectors (red ward or ICU) revealed that 3.1% of the transferred patients had a score of 0, 8.3% had scores between 1 and 3, and 30% had scores >3 (Table 2).

Regarding the length of hospitalization, a significant difference was observed between patients with BPEWS scores >3 and patients with a persistent score of 0 (p-value <0.001). Forty percent of the individuals with scores >3 were hospitalized for a period of 1-7 days, versus 66.3% of the patients with a score of 0. When the length of stay was longer than 30 days, the proportions were 15% and 2% for the respective groups of patients.

In the comparison against the reference scoring system[8], we found that 93.9% of the patients had a score of 0 in both scales, while only 10% of the individuals with scores > 3 in the BPEWS were categorized as normal (score=0) in the CARDIFF scale. On the other hand, of patients who scored ≥1 on the CARDIFF, 6.1% scored 0, 63% scored between 1 and 3, and 90% scored >3 on the BPEWS.

With 95% confidence, the BPEWS had an area under the ROC curve of 0.839 (0.791-0.887), which means that in 83.9% of the times when this scale was used, it discriminated between true positives and true negatives. Thus, we obtained an "n" equal to 19 for true positives and 224 for true negatives, when considering scores >3. The number of false positives was equal to 2 and false negatives to 80 for this same score.

DISCUSSION

In the present study, we observed a predominance of male children (58.5%) with a mean length of hospitalization of seven days, similarly to what Grunewald et al.[9] described. About 3% of hospitalized children need immediate care, and they account for most cases of increased morbidity and mortality[7]. In these cases, early recognition of signs and symptoms associated with severe disease is indispensable and a decisive factor for survival and good patient outcomes[6].

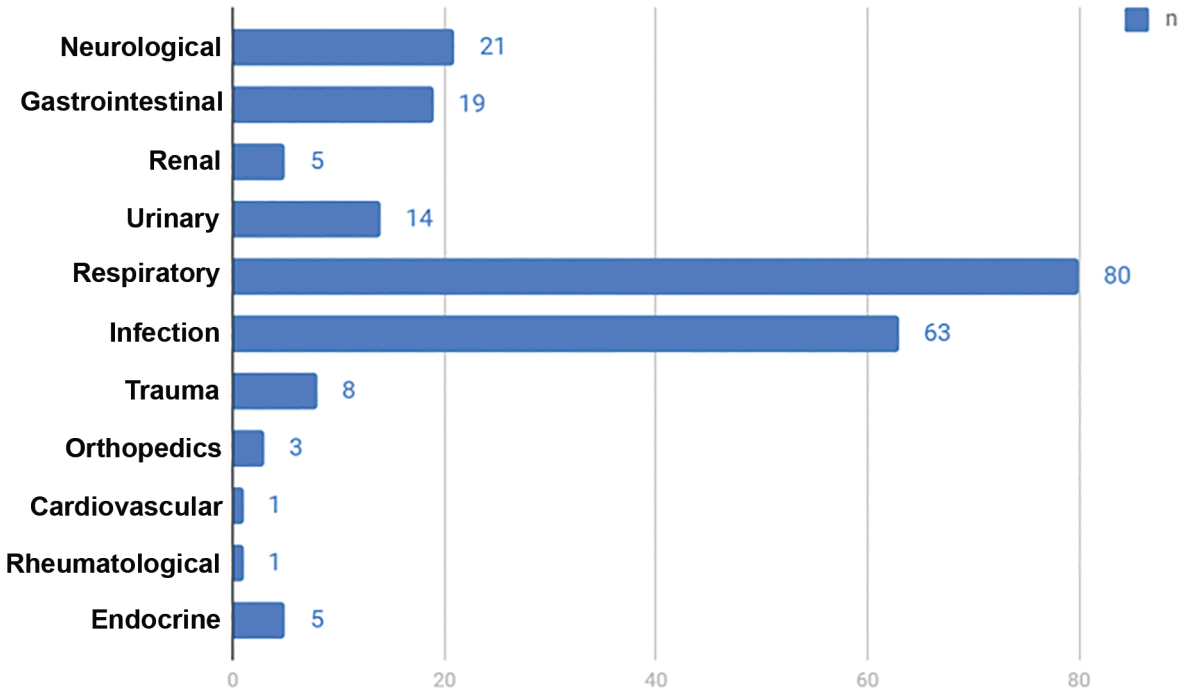
Table 1. Distribution of children aged 0-12 years admitted to the pediatric ward of a tertiary referral hospital according to age and length of stay.

Data	n (n=325)	%
Age		
1-6 months	39	12.0
7 months to 1 year	69	21.2
2-6 years	129	39.7
7-12 years	88	27.1
Length of hospital stay		
1-7 days	194	59.7
8-14 days	71	21.8
15-30 days	45	13.8
30+ days	15	4.6

The BPEWS is a scoring system based only on clinical components. It ranges from 0 to 13 points. Scores greater than 3 indicate increased risk of clinical worsening. The criteria used in the evaluation include neurological, cardiovascular, and respiratory parameters, use of oxygen therapy, and persistent postoperative vomiting[10]. In this context, the first three parameters have 0 as the minimum score and 3 as the maximum score, with the need to add 2 points for patients given nebulization within 15 minutes of the assessment (this process simulates a temporary improvement of respiratory parameters) or with persistent postoperative vomiting (more than three episodes). Each component has a "partial score", which, when added together, result in a "final score" that determines the risk of clinical worsening[6].

Based on the validity indicators obtained in this study, the comparison against the adopted reference standard showed that the BPEWS is a useful tool in identifying warning signs for clinical worsening in patients with scores ≥3, with sensitivity rated at 19.2%, specificity at 99.1%, positive predictive value (PPV) at 90.5% and negative predictive value (NPV) at 73.7%.

However, when compared to other studies[11-14], an important discrepancy in results was noticed in patient age. Tucker et al.[11] evaluated 2,979 patients aged 0-22 years and found, for scores ≥ 3, a sensitivity of 90.2%, a specificity of 74.4%, a PPV of 5.8%, and an NPV of 99.8%, a difference of 71%, 24.7%, 84.7%, and 26.1% for each respective item in our study. Akre et al.[13], in turn, included 186 patients aged two months to 21 years and analyzed the sensitivity of PEWS as an early indicator of patient worsening and found that 85.5% of the patients presented a critical score within 24 hours of clinical worsening, i.e., a difference of 66.3% in relation to our study. This discrepancy shows that age is a factor that can affect



Graphic 1. Distribution of medical causes of hospitalization of children aged 0-12 years admitted to the pediatric ward of a tertiary referral hospital.

Table 2. Assessment of need for referral to other sectors or hospitals and outcomes.

BPEWS scores	N (%)	ICU, n (%)	Other hospital, n (%)	Red ward, n (%)	Rehospitalization, n (%)
0	6 (3.1%)	1 (16.7)	0 (0)	1 (16.7)	4 (66.7)
1 - 3	9 (8.3%)	1 (11.1)	2 (22.2)	1 (11.1)	5 (55.6)
> 3	6 (30%)	3 (50)	3 (50)	0 (0)	0 (0)

results, since the BPEWS is a tool that is meant to be used in children up to 16 years of age, with use not recommended in older individuals[10].

As for the study scenarios, the BPEWS is an instrument that was designed to identify warning signs in children hospitalized in wards[10] and, therefore, most studies included children meeting this requirement so that their scores were valid [11, 13]. Gold et al.[12] also applied the BPWES in an emergency setting, only to find that the tool is insufficient to optimally measure the risk of clinical worsening of patients in emergency departments, which is not consistent with the value of 50% found in the analysis of the rate of referrals to an ICU for patients with scores >3. This shows, therefore, that the environment in which the scoring system is applied also affects the evaluation of its efficacy.

Nonetheless, other authors[10,15] reported results consistent with the ones found in our study. A study[10] published in 2017 included 271 children aged 0-10 years hospitalized in clinical-surgical and stabilization units of a pediatric hospital. Differences of 54.7% in sensitivity, 13.2% in PPV, 21% in NPV, and 3.6% in specificity were found in relation to our study.

Another study [15] also published in 2017 was carried out in a tertiary pediatric hospital with 297 patients under the age of 19 years to analyze the effectiveness of various scoring systems in patient evaluation. The Bedside PEWS showed 72% sensitivity, 89% specificity, a PPV equal to 86% and an NPV of 77%, with differences in relation to the present study of 52.8%, 10.1%, 4.5% and 3.3%, respectively. It is important to note that both authors evaluated the efficacy of this scoring system in a similar context with patients of similar age range to our study, which explains the minimal discrepancy in most of the reported results.

Furthermore, compared to the reference scoring system[15], the results of the BPEWS in our study showed better specificity and PPV values, which proves the importance of this scoring system in the early identification of clinical worsening in pediatric patients.

Supported by strong evidence of validity and reliability, the BPEWS is an extremely relevant and pertinent tool to identify pediatric patients at risk of clinical worsening. It helps medical teams to decide what needs to be done for each individual patient[5,16,17], since it includes the necessary components to assess the main neurological, respiratory, and

cardiovascular warning signs [6]. However, as discussed, many factors may affect the results of validation studies, including the absence of complete information in medical records and the non-attendance of patients in some stages of the study. Proper planning and execution are required to mitigate these issues.

The BPEWS is an easy-to-use tool that is very much suitable to the Brazilian reality, since the pediatric wards of Brazilian hospitals, especially the public ones, are short of monitoring equipment, have an insufficient number of beds in PICU, and a number of healthcare workers that is often inconsistent with patient demand[6]. This scoring system proved to be of great use, with consistent findings in terms of length of stay relative to the patient scores. When compared with a reference system with proven effectiveness (CARDIFF), the BPEWS stood its ground and produced satisfactory, consistent results.

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