

ORIGINAL ARTICLE

ACCURACY OF THE BEDSIDE PEWS SCALE IN DETERMINING CLINICAL DETERIORATION UPON ADMISSION OF PEDIATRIC PATIENTS

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Highlights:

- (1) Bedside PEWS assists with pediatric clinical assessment upon admission to the emergency department.
- (2) The use of PEWS strengthens pediatric patient safety by systematizing clinical assessments.
- (3) Bedside PEWS improved and contributed to better results in the real care setting.

ABSTRACT

Objective: To evaluate the accuracy of Bedside PEWS in determining clinical deterioration in pediatric patients upon admission. **Method:** Cross-sectional and retrospective study. A sample of 591 medical records of children admitted to a pediatric emergency department between January and December 2018. Data were analyzed using descriptive and inferential statistics. For each Bedside PEWS cutoff point, sensitivity and specificity were estimated, using transfer to intensive care as the outcome. A Receiver Operating Characteristic (ROC) curve was constructed based on these values. **Results:** Upon emergency admission, for PEWS >4, the ROC curve accuracy was 76.9%, with a sensitivity of 59.1% and specificity of 78.0% ($p < 0.001$). Upon transfer from the emergency department, for PEWS >5, the ROC curve accuracy was 87.4%, with a sensitivity of 72.6% and specificity of 94.3% ($p < 0.001$). **Conclusions:** Bedside PEWS is a valid tool for assessing clinical deterioration in children, with PEWS ≥ 5 being the most reliable indicator.

Keywords: hospital admission service; children's health; patient safety; pediatric nursing; early warning score.

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INTRODUCTION

Emergency and intensive care units receive critically ill patients requiring complex and immediate care to sustain life. Characterized by high patient demand and a wide range of severe conditions, pediatric emergency settings require even greater attention. These environments involve multiple professionals from various specialties and frequent patient transfers, necessitating heightened vigilance and precision to detect early signs of clinical deterioration.¹⁻³

The availability of resources for early identification and response to clinical deterioration in pediatrics positively impacts the quality of care provided. The Pediatric Early Warning Scores (PEWS) is a tool designed to assist healthcare professionals in identifying children at risk. This leads to enhanced monitoring and timely referral to teams with the appropriate expertise in emergency and intensive care. The scale consists of seven assessment items: four related to respiratory function and three to circulatory variations, aimed at detecting clinical deterioration. Additionally, it facilitates effective communication and the transfer of care, enhancing pediatric patient safety.^{2,4}

The PEWS scale is a classification designed to reflect trends in a child's physiological conditions, enabling early detection of deterioration and, consequently, prompt intervention in hospitalized children. It serves as a standardized criterion and language for multidisciplinary teams, ensuring uniform assessment and improving communication among healthcare professionals. These tools have been developed and validated since 2005, based on similar instruments used in adult populations. Bedside PEWS was introduced in 2009 to simplify the assessment of clinical deterioration in pediatric patients. In Brazil, studies utilizing PEWS indicate that this tool quantifies disease severity in hospitalized children and identifies severe conditions at least one hour in advance. Effective communication and accurate documentation in medical records are essential to ensure that the initial assessment is faithfully recorded, reflecting the appropriate score^{5,6}.

Rapid and precise decision-making regarding critically ill patients and their future care needs is crucial to preventing adverse events and optimizing resource use. This plays a key role in Knowledge Translation (KT), ensuring that interventions, clinical recommendations, and decisions are based on the best available evidence and aligned with the clinical context⁷. Systematic processes reduce the risk of care discontinuity. During care transitions, direct, clear, and concise information sharing enhances patient safety and minimizes the risk of errors that could lead to conflicts, workplace disorganization, compromised patient care, and adverse events^{8,9}.

The contribution of early warning scales extends across various healthcare settings, as professionals increasingly rely on these tools to make nursing care more humanized, technologically advanced, scientifically grounded, and robust¹⁰. KT presents an excellent opportunity to improve healthcare quality through the adoption of validated scales. These tools enable healthcare institutions to leverage innovative scientific products supported by studies evaluating their clinical utility⁷.

Improving patient care quality requires understanding the factors that predispose to errors, implementing strategies to mitigate them, and adopting tools that facilitate this process. This study aimed to evaluate the accuracy of Bedside PEWS in determining clinical deterioration in pediatric patients upon admission.

METHOD

This was a retrospective, cross-sectional study with a quantitative approach, conducted in the Pediatric Emergency Unit (PEU) of a university hospital in southern Brazil. The study follows the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) initiative. The PEU serves patients from birth to 14 years old, who either seek care spontaneously or are referred from

other units for urgent or emergency conditions. Upon arrival at the PEU, patients are assessed by a nurse and receive care based on risk classification. Depending on clinical severity, patients may be admitted to the PEU observation room, require hospitalization, or be transferred to other pediatric units. In such cases, patients undergo Bedside PEWS assessment both at admission and at the time of transfer.

A simple random sample was drawn from the medical records of children admitted to the PEU in 2018 and subsequently transferred to pediatric units, including the surgical ward, inpatient units, or Pediatric Intensive Care Unit (PICU). Data collection took place between June and November 2019. Neonates and children with a primary diagnosis of cardiological disease, for which a validated early warning score already exists, and oncological conditions, due to the scale's lack of sensitivity for this population, were excluded from the study^{2,5}.

The sample size calculation was based on a study evaluating clinical deterioration in Brazilian children, which reported 90% sensitivity and 75% specificity for the most accurate cutoff point of the instrument used². Considering these parameters, along with a 95% confidence level and a 0.05% margin of error, the minimum sample size for this study was estimated at 579 medical records.

The medical records were identified through a query requested from the database of the Medical Records and Health Information Service (*Serviço de Arquivo Médico e Informação em Saúde*, Samis), including records of patients transferred from the emergency department to the PICU and pediatric inpatient units during 2018. A total of 1,039 medical records meeting the inclusion criteria were retrieved, organized in ascending order by admission date, and randomly selected to meet the minimum sample size previously calculated. Records of patients transferred to oncology and neonatal treatment units were excluded due to the scale's lack of sensitivity to the specific conditions of these populations. The final sample consisted of 591 medical records, collected using a structured form. The variables included gender, age, place of origin, primary caregiver, previous pathological history, diagnosis at PEU admission, PEWS scores at PEU admission, length of stay in the PEU, PEWS scores at PEU transfer, and transfer unit (surgical ward, inpatient unit, or intensive care unit). Records of patients transferred to oncology and neonatal treatment units were excluded due to the scale's lack of sensitivity to the specific conditions of these populations.

The data were obtained through a query in an electronic spreadsheet and supplemented by access to a database maintained by the Emergency Nursing Service, which monitors pediatric patients based on the PEWS scale. Data collection took place from June to November 2019, following approval of the study protocol by the institution's Research Ethics Committee.

The PEWS scale used in the PEU is a translated version of Bedside PEWS⁵, implemented in the institution in 2018. The scale consists of seven assessment items: four related to respiratory function and three to circulatory variations, including heart rate, blood pressure, capillary refill time, respiratory rate, respiratory effort, oxygen saturation, and oxygen therapy. These parameters can be assessed in both awake and sleeping children, quickly and at the bedside. The final score on this instrument ranges from 0 to 26 points, derived from partial scores based on the evaluated parameters. A score of 7 or higher was defined as an indicator for additional interventions by the healthcare team, while a score between 0 and 6 indicated clinical stability, with no need for further interventions⁵.

Data analysis was performed using the Statistical Package for the Social Sciences (SPSS) version 18.0 and MedCalc Statistical software. Descriptive statistics and the Chi-square test were used to compare proportions of categorical data. The accuracy of the PEWS scale was assessed by calculating sensitivity, specificity, the Receiver Operating Characteristic (ROC) curve, and the area under the ROC curve, with transfer to the PICU used as the reference standard. The median PEWS scores across different care units were compared using the Mann-Whitney test.

This study was approved by the institution's Research Ethics Committee under approval number 3.403.556 (CAAE: 12688919.2.0000.5327).

RESULTS

A total of 591 medical records were eligible for the study. The median age of the children was 12.8 months (4.0-44.5). Of the total sample, 69 children (11.7%) had two or more hospital admissions. Additional sociodemographic and clinical data are presented in Table 1.

Table 1 – Sociodemographic and clinical characteristics of the children admitted to the Pediatric Emergency Unit (n=591)

Characteristics	n (%)
Gender	
Male	333 (56.3)
Female	258 (43.7)
Primary caregiver	
Mother	547 (92.6)
Father	28 (4.7)
Institutionalized	3 (0.5)
Others	13 (2.2)
Origin	
Capital	313 (53.0)
Metropolitan region	189 (32.0)
Inland	74 (12.5)
Outside state of Rio Grande do Sul	15 (2.5)
Reason for admission	
Respiratory dysfunction	288 (48.7)
Gastrointestinal dysfunction	92 (15.6)
Acute pain	55 (9.3)
Fever	49 (8.3)
Seizure crisis	26 (4.4)
Cardiorespiratory arrest	3 (0.5)
Other	78 (13.2)
Previous pathological history	
Yes	337 (57.0)
No	254 (43.0)

The primary diagnoses for hospitalization, as recorded in electronic medical records according to the International Classification of Diseases (ICD-10), were categorized as follows: respiratory system diseases (51.8%); digestive system diseases (16.8%); nervous system diseases (7.1%); genitourinary

system diseases (5.4%); and endocrine, nutritional, metabolic, and immune system diseases (3%). Infectious and parasitic diseases, hematologic diseases, and other conditions accounted for 15.9% of cases. Among respiratory system diseases, 34.2% of children were hospitalized for bronchiolitis, 12.7% for bronchopneumonia, and 2.7% for bronchospasm.

Upon admission to the PEU, children were assessed using PEWS as part of the care protocol. The PEWS score was recorded in 403 (68.2%) medical records. The median PEWS score at admission was 3 (1.0/5.0). When PEWS scores were categorized based on the need for additional interventions by the healthcare team, 46 cases (11.4%) were identified as requiring such interventions (PEWS ≥ 7) ($p \leq 0.05$).

The median length of stay in the PEU was 1 day (0-12), after which patients were transferred to other units. PEWS was applied to 537 (90.7%) children just before their transfer from the PEU to other care units: surgical ward, inpatient unit, or PICU. The median PEWS score at transfer was 7.0 (5.0-9.0) for the PICU, 2.0 (1.0-4.0) for the inpatient unit, and 1.0 (0.5-2.0) for the surgical ward ($p \leq 0.05$). When PEWS scores were categorized based on the need for additional interventions by the healthcare team, 65 (12.1%) transfer cases were identified as requiring such interventions (PEWS ≥ 7) ($p = 0.001$), as shown in Table 2.

Table 2 – PEWS scores at transfer for the children admitted to the Pediatric Emergency Unit

	PEWS Score		N (%)	p
	n (%)			
	0-6 ^a	≥ 7 ^b		
Hospitalization	411 (98.6)	6 (1.4)	417 (77.6)	0.000*
Surgical ward	25 (100)	0 (0)	25 (4.7)	0.147
Pediatric Intensive Care Unit	36 (37.9)	59 (62.1)	95 (17.7)	0.000*
TOTAL	472(87.9)	65 (12.1)	537 (100)	0.001*

^a The score does not require additional interventions by the healthcare team.

^b The score requires additional interventions by the healthcare team.

* p-value ≤ 0.05 . Chi-square test.

Of the total children admitted to the PEU and transferred to the PICU (110; 18.61%), 59 (62.1%) were assessed using PEWS at PEU admission, of whom 42 (71.2%) had PEWS ≥ 7 ($p = 0.0459$). At the time of transfer to the PICU, a PEWS score > 4 was identified as the optimal cutoff point for transfer, with children scoring ≤ 4 classified as “without warning signs” and those scoring > 4 as “with warning signs of clinical deterioration.”

The area under the ROC curve between the PEWS score at PEU admission and the reference standard (transfer to the PICU) was 0.769 (95% CI: 0.725-0.809; $p < 0.0001$), meaning that in 76.9% of cases, PEWS correctly identified true positives and true negatives for clinical deterioration, while in 23.1% of cases, the scale provided false results. At PEU admission, a PEWS score > 4 was the cutoff point that maximized sensitivity (59.1%) and specificity (78.0%), achieving the highest accuracy (76.9%). Conversely, a PEWS score > 5 was identified as the optimal cutoff point at the time of transfer from the PEU, with children scoring ≤ 5 classified as “without warning signs” and those scoring > 5 as “with warning signs of clinical deterioration.” The area under the ROC curve between the PEWS score at PEU transfer and the reference standard was 0.874 (95% CI: 0.843-0.901; $p < 0.0001$), meaning that in 87.4% of cases, PEWS correctly identified true positives and true negatives for clinical deterioration, while in 12.9% of cases, the scale provided false results. At the time of transfer from the PEU to the PICU, a PEWS score > 5 was the cutoff point that maximized sensitivity (72.6%) and specificity (94.3%), achieving the highest accuracy (87.4%) (Figure 1).

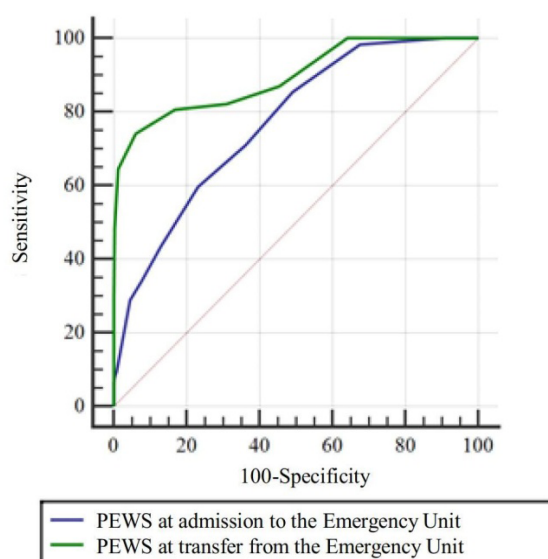


Figure 1 – ROC Curve for PEWS at admission and transfer from the Pediatric Emergency Unit, compared to the reference standard in the study sample.

The distribution of PEWS validity indicators at admission and transfer from the PEU, relative to the reference standard (transfer to the PICU), based on the optimal cutoff point obtained from the ROC curve, is detailed in Table 3. The scale demonstrated an accuracy of 76.9% when used at admission and 87.4% at transfer, values considered statistically satisfactory¹¹. Sensitivity, or the ability to correctly identify children at risk of clinical deterioration, was 59.1% at admission and 72.6% at transfer.

Table 3 – Performance measures for PEWS cutoff points relative to the reference standard

	N	n (%)*	CP	Validity indicators			p**
				Sensitivity	Specificity	Accuracy	
				CI (95%)			
Admission ^a	403	66 (16.4)	>4	59.09 (46.3-71.0)	78.04 (73.2-82.3)	0.769 (0.725-0.809)	<0.0001
Transfer ^b	537	95 (17.7)	>5	72.63 (62.5-81.3)	94.34 (91.8-96.3)	0.874 (0.843-0.901)	<0.0001

^a PEWS at admission to the Pediatric Emergency Unit (PEU) and transfer to the Pediatric Intensive Care Unit (PICU).

^b PEWS at transfer from the PEU to the PICU.

CP = Cutoff Point.

*N = Number of patients transferred to the PICU.

** p-values<0.05. ROC curve

DISCUSSION

Bedside PEWS is a valuable tool for ensuring the safety of pediatric patients at risk of clinical deterioration. In Brazil, the use of standardized clinical guidelines has been encouraged to improve healthcare quality, and the scale proved useful when applied in the PEU at both admission and transfer to other units. Research evaluating the sensitivity and specificity of clinical practice scales contributes to the translation of knowledge into pediatric inpatient care.

Caring for critically ill children with hemodynamic instability and a risk of clinical deterioration is complex and demanding. The likelihood of adverse events in pediatrics is up to three times higher than in adults^{12,13}. The probability of adverse events is directly proportional to patient severity and the complexity of required treatments, characteristics frequently observed in pediatric emergency and intensive care units¹⁴.

The use of standardized assessment tools improves patient safety. PEWS enhances communication among multidisciplinary teams and improves documentation, facilitating information sharing, particularly during care transitions. Healthcare professionals gain greater confidence in conveying objective data about a child's clinical condition¹⁵.

A cross-sectional study identifying factors associated with clinical deterioration in pediatric patients highlighted that age under two years, the presence of comorbidities, respiratory diagnoses, and admission to an emergency unit are associated with higher rates of clinical deterioration⁴. Studies report higher morbidity and mortality among male children, possibly due to greater exposure to injuries such as burns and falls^{3,4,16,17}. Based on these findings, it can be concluded that the study sample primarily consisted of children at risk of clinical deterioration, given that the median age was under two years (12.8 months), 69 children (11.7%) had two or more hospital admissions within the year, the majority had comorbidities (57%), and nearly half (48.7%) had respiratory dysfunction diagnoses.

In pediatrics, the decision to seek emergency medical care is often driven by parental or caregiver concerns about a child's symptoms. Respiratory dysfunctions accounted for 48.7% of pediatric emergency visits. Brazilian studies indicate that respiratory diseases are the most prevalent, with 30–50% of children seeking emergency care presenting respiratory symptoms^{3,16-18}. Globally, respiratory infections are a major burden on healthcare systems, representing the most frequent reason for emergency visits and leading to thousands of hospitalizations annually^{16,17-19}. PEWS includes four items specifically assessing respiratory patterns, which directly impact clinical deterioration.

In this study, the median length of stay in the PEU was 1 day (0-12). Emergency care prioritizes immediate treatment for critically ill patients²⁰. Even lower-risk patients requiring hospital treatment should not remain in the emergency department for more than 24 hours, as prolonged stays increase the risk of adverse events²¹. Length of stay is closely associated with disease severity and complications²².

The proportion of children assessed using PEWS at admission was below 70%, suggesting that adherence to the protocol was still in its early stages and required further training to reinforce its importance and utility. Timely provision of care and resources improves patient outcomes^{23,24}. Thus, early warning scores should be regarded as comprehensive patient safety systems that help identify and manage patients at higher risk of adverse outcomes^{23,25,26}.

At the time of PEU admission, 11.4% of children had a PEWS score ≥ 7 , indicating the need for additional interventions by the healthcare team. A large prospective cohort study evaluated ten different PEWS scores published internationally, comparing their ability to predict the need for admission to pediatric intensive care units. The study highlighted that PEWS tools can be used as supplementary instruments to identify patients at risk of clinical deterioration, indicating the need for PICU admission and, with lower accuracy, the need for hospitalization²⁴.

There was a significant difference ($p=0.012$) between the transfer PEWS scores of children admitted to the PICU (median 7.0) and those admitted to general inpatient units (median 2.0). A Bedside PEWS validation study confirmed its ability to distinguish patients requiring advanced care in the PICU at least one hour in advance. In a validation study, a PEWS score of 7 or higher correctly identified 1,263 out of 1,388 patients (91%) who did not experience clinical deterioration during hospitalization²³. Patients requiring urgent PICU admission had higher PEWS scores (median 7) than those who did not require intensive care (median 4), with a significant difference ($p<0.001$)⁵.

Clinical validation studies rely on establishing a cutoff point that balances sensitivity and specificity. Although the values varied depending on the timing of scale application, this study concluded that a Bedside PEWS score ≥ 5 provided the best performance and balance between sensitivity and specificity for the studied population.

The cutoff point differed between this study (≥ 5) and the Bedside PEWS validation study (≥ 7). This discrepancy may be attributed to various factors, including differences in organizational culture across countries where the studies were conducted, as well as distinct population needs. Additionally, the timing of PEWS application relative to the deterioration event or transfer may have influenced these findings. In this study, due to a lack of records, it was not possible to determine precisely how many hours before the event or transfer PEWS was applied. The development and validation study of the scale demonstrated a progression in PEWS scores as the need for urgent PICU admission approached. While maximum mean scores ranged between 5 and 6 when assessed more than 12 hours before PICU admission, they increased to 9.5 when assessed 0 to 3 hours before admission⁵.

There is no established gold standard for evaluating clinical deterioration scales; therefore, this study used unplanned PICU transfer as the outcome measure. Similar studies have employed the same criteria to assess severity and clinical deterioration^{23,24,26,27}.

To compare the performance of different PEWS tools in pediatric emergency settings, a prospective cohort study analyzed the use of ten different scales in 17,943 children under 16 years of age over four years at a university hospital in the Netherlands. The study found that areas under the ROC curve, considering unplanned PICU admission as the outcome, ranged from 0.60 to 0.82, with sensitivity between 61.3% and 94.4% and specificity between 25.2% and 86.7%²⁴.

Bedside PEWS has not been clinically validated or culturally adapted for the Brazilian context. The development and use of clinical assessment scales is a complex process requiring significant resources and expertise. In many cases, adapting an existing tool accelerates this process and allows for broader generalization of results. However, selecting an instrument developed in a different language, context, and culture for use in distinct settings is a delicate process, requiring rigorous methodology to ensure its validity and effectiveness across different realities^{28,29}.

The knowledge translation derived from this research provides valuable insights for nurses, enhancing their understanding and improving the implementation of early warning scores in clinical practice. Without the knowledge translation phase, research findings are not incorporated into real-world healthcare settings, making this an essential step that extends beyond the methodological design of the study³⁰. In this regard, it is possible to affirm that the implementation of Bedside PEWS improved clinical practice at the institution and contributed to better healthcare outcomes, with the scale being fully integrated into the hospital's electronic system the year after its implementation.

CONCLUSIONS

The results demonstrated that Bedside PEWS is a valid tool for assisting in pediatric clinical assessment at emergency unit admission and prior to interunit transfers. However, PEWS scores ≥ 5 should be considered indicators of clinical deterioration. The use of PEWS enhances pediatric patient safety by systematizing objective and frequent clinical assessments based on vital signs monitoring and physical examination. Through Bedside PEWS, knowledge translation was observed, as it facilitated improvements in pediatric patient clinical assessment. This integration addresses a need identified by researchers and healthcare professionals, aiming to improve healthcare system efficiency by identifying critically ill patients at risk of clinical deterioration.

The limitations of this study include the lack of structured data and the absence of validation of the scale for the Brazilian context. Key implications of this study include the need for reviewing

and improving protocols, promoting the scale through training and continuous education, conducting further research on the use of Bedside PEWS in Brazil, and initiating efforts to translate and validate the scale for the Brazilian healthcare setting.

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