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ORIGINAL ARTICLE

ACCURACY OF TWO PEDIATRIC EARLY WARNING SCORES FOR CLINICAL DETERIORATION IN THE BRAZILIAN CONTEXT

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ABSTRACT

Objective: To compare the accuracy and reproducibility of the *Escore Pediátrico de Alerta* (EPA) and the Brazilian version of the Brighton Paediatric Early Warning Score (BPEWS-Br) in the identification of signs of clinical deterioration in the Brazilian context. **Methodology:** diagnostic test accuracy study, carried out in a large maternal and child hospital, with 240 children and adolescents aged 0 to 15 years, from October 2018 to May 2019. The instruments for collection were the BPEWS, the EPA and the criteria for the primary clinical assessment of critically ill children recommended by the American Heart Association as the reference standard. The data were analyzed using MedCalc® Statistical Software, version 20.007, to estimate indicators of accuracy and agreement between the scores. **Results:** the EPA ranged from 0 to 7 and the BPEWS-Br from 0 to 8. Considering a score ≥ 3, the EPA had a prevalence of deterioration of 19.5%, the BPEWS-Br of 16.7% and the reference standard of 22.1%. The areas under the ROC curves of the BPEWS-Br and the EPA were practically equal, 93.5% (CI: 90 – 97) and 93.6% (CI: 89.8 – 97.4), respectively, which shows high accuracy of the tests. The Kappa Index between the scores was 0.879 (95% CI: 0.845 to 0.912), showing high agreement. **Conclusion:** the accuracy and reproducibility indicators of the BPEWS-Br and the EPA were high.

Palavras-chave: Early Warning Scores. Clinical Deterioration. Pediatric Nursing. Sensitivity and Specificity.

INTRODUCTION

Pediatric Early Warning Scores (PEWS) are measurement tools developed to help health professionals, especially nurses, to recognize children who are deteriorating clinically in a hospital environment. They are considered simple technologies, developed for bedside application, using clinical parameters that are easy to measure, without the need for invasive procedures, complex equipment or high costs[1-4].

The purpose of a PEWS is to support the early identification of warning signs and trigger immediate care that avoids the progression of clinical worsening and unfavorable outcomes, such as admission to an intensive care unit, progression to cardiac arrest and death[1-4].

Many PEWS have been published in the scientific literature. They were originally developed internationally, adapted from scores used in the adult population and validated in different countries. There are currently dozens of original PEWS or scores modified/adapted from other scores for the care of hospitalized children[1,4,5].

Some factors can interfere with the adoption of PEWS by health services, such as the characteristics of the system itself, its complexity, validity and applicability, as well as the cultural and organizational context. The involvement of staff members in the safety culture, their ongoing training and supervision, the availability of personnel and standardized processes are important requirements for its implementation[1].

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Given the evidence of its validity in terms of recognizing pediatric clinical deterioration in a variety of settings around the world, health services in certain countries recommend that hospitals implement PEWS, in order to avoid adverse events, prevent complications and provide better safety for pediatric patients[1,6,7].

In Brazil, to date, there is no standard national recommendation for the use of PEWS in a hospital environment, and there are still few published studies on the validation of these scores in Brazilian contexts, among which the following stand out: the Brazilian version of the Brighton Paediatric Early Warning Score (BPEWS-Br)[2] and the *Escore Pediátrico de Alerta* (EPA, as per its Portuguese acronym), designed and validated based on the BPEWS-Br[8,9].

The BPEWS-Br was validated on a sample of 271 children between the ages of 0 and 10. It is made up of nine clinical criteria and its final score can vary from 0 to 13 points. In turn, the study to validate the EPA used a sample of 240 children and adolescents aged 0 to 15, and it also has nine clinical criteria and its final score ranges from 0 to 11. For both instruments, cutoff point 3 was defined as having the best accuracy in terms of identifying clinical deterioration. Both the BPEWS-Br and the EPA were validated in the same hospital setting, but at different times, and showed good indicators of accuracy and reproducibility in terms of identifying pediatric patients in clinical deterioration[2,8,9], but have not yet been compared.

Based on the above and the lack of research comparing the performance of the two tools in the same sample, this study posed the following research question: what is the accuracy and reproducibility of the BPEWS-Br and the EPA in terms of identifying clinical deterioration when applied to the same research sample in the Brazilian context? Therefore, the objective of the study was to compare the accuracy and reproducibility of the *Escore Pediátrico de Alerta* (EPA) and the Brazilian version of the Brighton Paediatric Early Warning Score (BPEWS-Br) in terms of identifying signs of clinical deterioration in the Brazilian context.

The study is justified and relevant due to the lack of national research comparing the performance of PEWS already validated in Brazil. It could also help to produce evidence to allow health services and professionals to choose a validated pediatric alert score that is applicable to their clinical practice, since there are still no formal recommendations for the use of PEWS by the health authorities of the country.

METHODOLOGY

A prospective diagnostic test accuracy study was conducted to compare the accuracy and reproducibility of the BPEWS-Br and the EPA in terms of identifying clinical deterioration in children and adolescents. In order to help to elaborate the manuscript, the guidelines of the Standards for the Reporting of Diagnostic Accuracy Studies (STARD), an instrument developed to improve the quality of diagnostic test accuracy study reports, were followed[10,11].

The study settings were the inpatient units of the medical and surgical clinics and the emergency department of a large maternal and child hospital, in order to include patients who were likely to deteriorate. The hospital that served as the study site has 240 beds and is located in the countryside of Bahia – Brazil, with an approximate population of 615,000 inhabitants. It is a reference service for patients aged 0 to 15 in the city and surrounding region.

The reference population was consisted of children and adolescents aged 0 to 15 who were hospitalized during the study period, regardless of length of stay. The sample calculation adopted the formula $N = 1.96^2$ [0.17 (1-0.17) / (0.05^2)], adding a further 10% to the value, considering losses. The proportion of clinical deterioration adopted for the sample calculation was 17%, based on a previous study[2]. The Confidence Interval (CI) spectrum was 0.10, the acceptable error was 0.05 and the Z value was 1.96. The calculated sample, taken from the database of the parent project to which this study is linked, was 240 patients.

The inclusion criteria for the patients were to be aged between 1 month and 15 years, with a record of hospitalization in the medical charts, admitted to the clinical and surgical units, on spontaneous ventilation, without restrictive measures for visits and with a companion/guardian present at the time of the

assessment made by the researchers. The study participants were selected by drawing lots in the units, on each day of collection, from the list of inpatients, which was generated by the hospital system. In order to collect the data, the responsible companion signed the Consent Form and patients over the age of 7 agreed to take part, in order to comply with ethical recommendations.

The adopted exclusion criteria were: medical discharge, diagnosis of heart disease and oncology described in medical charts, newborns, isolation and use of mechanical ventilation. Patients with heart disease, oncology and newborns were excluded because the two scores have not been validated for these populations, while patients in isolation were excluded to avoid cross-infection during data collection, as well as those on mechanical ventilation because it was impossible to assess their breathing pattern.

The instruments used for data collection were the BPEWS-Br, the EPA and the reference standard. The clinical assessment criteria of the BPEWS-Br are state of consciousness, breathing pattern, Respiratory Rate (RR), oxygen support, skin color, Capillary Refill Time (CRT), Heart Rate (HR), use of nebulization and post-surgical vomiting[2]. In turn, the assessment criteria included in the EPA are state of consciousness, breathing pattern, RR, oxygen support, skin color, CRT, HR, temperature and diuresis[9]. The reference standard used to determine the presence or absence of clinical deterioration is the set of criteria for the primary clinical assessment of the critically ill child, recommended by the American Heart Association[12]. All the assessment criteria of the instruments were standardized for application, in order to train observers and minimize measurement bias.

The data was collected from October 2018 to May 2019 by a nurse trained in terms of applying the scores and by a pediatrician trained in terms of assessing the reference standard. The applications of the BPEWS-Br and the EPA by the nurse and the reference standard by the physician were performed blindly, with a 5-minute interval between assessments. A pilot test was carried out on 20 children to test the instruments and adapt the collection to the dynamics of the service.

It is worth underlining that, despite the fact that, in the first validation study of the BPEWS for the Brazilian context, the original score was applied to children aged 0 to 10 years[2], this study expanded the age range of validation of the BPEWS-Br to children and adolescents aged 0 to 15 years, which may add more value to this instrument.

The data was processed electronically and analyzed using MedCalc® Statistical Software, version 20.007 (MedCalc Software Ltd., Ostend, Belgium; https://www.medcalc.org; 2021), in order to estimate the accuracy indicators of the BPEWS-Br and the EPA in comparison with the reference standard. For the qualitative variables, absolute and relative frequencies were calculated. For the continuous quantitative variables, means and medians were calculated with the respective Standard Deviation (SD) and Interquartile Range (IQR). The following items were used as indicators to measure the accuracy of the two scores: Sensitivity, Specificity, Youden Index, Positive Likelihood Ratio (LR+), Positive Post-Test Probability (PPT+) and Receiver Operating Characteristic Curve (ROC curve). The weighted Kappa index was calculated as the coefficient of agreement between the scores, in order to maintain the hierarchy related to the severity of the cases among the categories of the score[11].

The study was approved by the Research Ethics Committee of the State University of Feira de Santana (UEFS, as per its Portuguese acronym), under CAAE nº 79484117.2.0000.0053, and is linked to the research project "Recognition of pediatric clinical deterioration in the hospital context of child health in the city of Feira de Santana – Bahia – Brazil", belonging to UEFS, funded by the National Council for Scientific and Technological Development (CNPq, as per its Portuguese acronym), Call MCTIC/CNPq nº 28/2018, Process nº 405101/2018-0.

RESULTS

Flow of the participants

The flow of the participants in the diagnostic test accuracy study, as recommended by STARD, is shown in Figure 1.

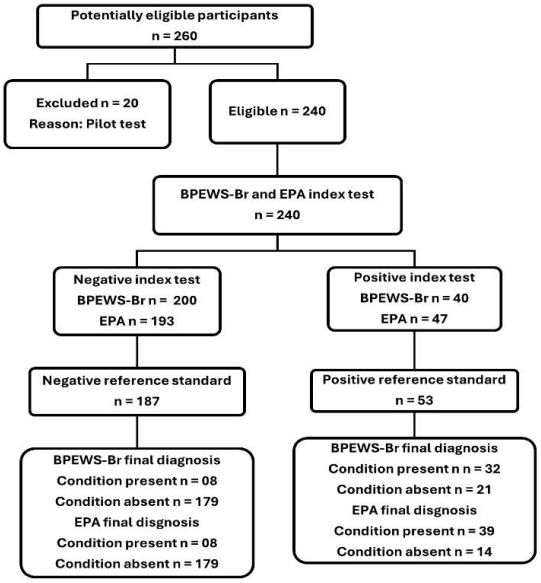

Figure 1. Flow of the study participants.

Characterization of the participants

Of the children and adolescents who took part in the study, 20.9% were <1 year old, 41.6% were between 1 and 5 years old, 23.7% were between 6 and 10 years old and 13.8% were between 11 and 15 years old. The mean age was 4.6 years (SD: 0;28), while the median was 4.0 years [IQR: 1;8]. As for biological sex, 51.7% were males. Table 1 shows the distribution of the final scores of the participants obtained from the BPEWS-Br and the EPA.

Table 1. Distribution of the final scores obtained from the application of the BPEWS-Br and the EPA in hospitalized children and adolescents. Feira de Santana, 2020.

Final scores	*BPEWS*-Br			EPA		
	n (240)	%	% cumulative	n (240)	%	% cumulative
8	1	0.4	0.4	-	-	0.0
7	1	0.4	0.8	7	2.9	2.9
6	3	1.3	2.1	2	0.8	3.7
5	8	3.3	5.4	6	2.5	6.2
4	5	2.1	7.5	13	5.4	11.6
3	22	9.2	16.7	19	7.9	19.5
2	15	6.3	23.0	22	9.2	2.7
1	46	19.2	42.2	62	25.8	54.5
0	139	57.8	100	109	45.5	100

Source: original data

Based on Table 1, the EPA score ranged from 0 to 7 points and the BPEWS-Br score from 0 to 8 points, with 0 being the absence of signs of deterioration and/or severity and 8 being the greatest severity. Considering the cutoff point ≥ 3, recommended by the studies that validated the BPEWS-Br and the EPA to trigger an initial alert of the risk of clinical worsening by the patient, the prevalence of deterioration of the EPA was 19.5% and the BPEWS-Br was 16.7%. In turn, according to the reference standard adopted in the study, the prevalence in the study sample was 22.1%.

Score accuracy

Table 2 and Figure 2 describe the indicators calculated to measure the accuracy of the BPEWS-Br and the EPA in terms of identifying clinical deterioration compared to the reference standard.

Table 2. Distribution of the BPEWS-Br and EPA cutoff points obtained in the sample according to their values of Sensitivity, Specificity, Youden Index, Positive Likelihood Ratio and Positive Post-Test Probability. Feira de Santana, 2020.

Scores	BPEWS-Br					EPA				
	SE (%)	SP (%)	Y	LR+	PPT+ (%)	S (%)	E (%)	Y	LR+	PPT+ (%)
≥ 0	100	0.0	0.0	1.0	21.8	100	0.0	0.0	1.0	21.8
≥ 1	98.1	73.8	0.71	3.7	50.9	98.1	57.0	0.55	2.3	39.2
≥ 2	79.2	93.0	0.72	11.4	76.2	86.8	87.7	0.74	7.0	66.2
≥ 3	60.4	95.7	0.56	14.1	80.0	73.6	95.7	0.69	17.2	82.9
≥ 4	26.4	97.9	0.24	12.5	77.7	49.1	98.9	0.48	44.6	92.6
≥ 5	24.5	100.0	0.24	-	-	26.4	99.5	0.26	52.8	93.7
≥ 6	9.4	100.0	0.09	-	-	17.0	100	0.17	-	-
≥ 7	3.8	100.0	0.04	-	-	13.2	100	0.13	-	-
≥ 8	1.9	100.0	0.02	-	-	100	100	0,0	-	-

Source: original data

SE: Sensitivity; SP: Specificity; Y: Youden; LR+: Positive Likelihood Ratio; PPT+: Positive Post-Test Probability.

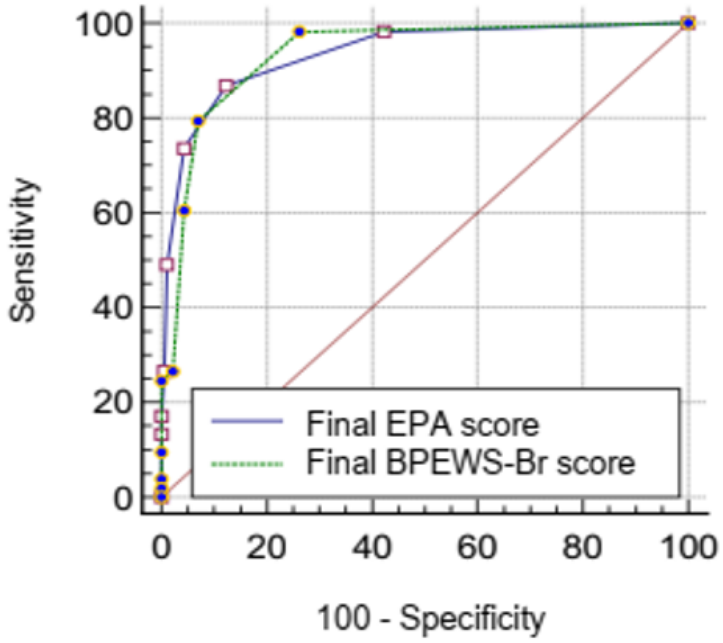

Figure 2. ROC curves and areas under the ROC curves of BPEWS-Br and EPA

According to Table 2 and the ROC curve (Figure 2), considering the values of Sensitivity and Specificity and the Youden Index of the scores measured in the sample, the cutoff point ≥ 2 would be the most recommended to recognize clinical deterioration for both BPEWS-Br and EPA, since this score balances the values of Sensitivity and Specificity (located in the upper left corner of the ROC curve), which obtained the best Sensitivity and Specificity Youden Indexes. However, considering the Positive Post-Test Probability (PPT+), an indicator of the usefulness of the test, the BPEWS-Br and the EPA cutoff points ≥ 3 would increase the pre-test probability of deterioration from 22.1% to 80% and 82.9%, respectively.

Also in Figure 2, the areas under the ROC curves of the BPEWS-Br and the EPA were calculated, in order to present the overall accuracy of the tests, i.e., the ability to correctly discriminate

healthy and sick individuals. The results showed high and practically equal accuracies, of 93.5% (CI: 90 – 97) and 93.6% (CI: 89.8 – 97.4), respectively, when compared to the reference standard adopted for the recognition of clinical deterioration in the studied sample.

Assessment agreement between the scores

The weighted Kappa Index calculated to verify the agreement between the BPEWS-Br and the EPA was 0.879 (95% CI: 0.845 to 0.912), which means an almost perfect degree of agreement between the two instruments (0.81-1.00).

DISCUSSION

The use of health measurement instruments to help professionals to assess and identify pediatric clinical deterioration at an early stage, based on simple and objective clinical criteria, is a worldwide trend, which has led many services to adopt the so-called Pediatric Early Warning Scores (PEWS) in their care spaces[1,13,14]. This is because the prevalence of clinical deterioration in pediatric hospitals is a relatively common phenomenon, with estimates ranging from 8 to 20%[2,13,14], which reflects the importance of validating tools for the early recognition of this phenomenon, given the possibilities of instituting interventions and preventing unfavorable outcomes for patients and services.

The ability to recognize pediatric clinical worsening is essential for the adoption of PEWS in a care setting. In this sense, it is necessary to know its validity and reliability already tested in similar contexts, in order to detect clinical worsening with a certain degree of certainty, accuracy and safety. In addition, nurses must be properly trained before its implementation, in order to strengthen the results and communication between professionals[15].

This study compared the accuracy and reproducibility of two PEWS, the EPA and the BPEWS-Br, already validated in Brazil for the recognition of pediatric clinical deterioration, in order to verify the performance of the scores in the same sample. The results are encouraging, showing high indicators of accuracy and reproducibility, whose results are corroborated by other studies that have validated PEWS in various contexts[13,14,15,16].

A prospective observational study in India of 738 children aged 1 month to 12 years verified the validity of PEWS for predicting clinical deterioration on admission to the emergency department and one hour after admission to the ward. ICU admission or transfer was adopted as the reference standard. The study found that cutoff point 2 was ideal for both moments (areas under the ROC curve of 0.76 in the emergency department and 0.78 in the ward). The Sensitivity, the Specificity and the Positive Likelihood Ratio on admission were 67.4%, 76.3% and 2.85%, respectively; but, after one hour in the ward, the sensitivity was 61.9%, the Specificity 88.89% and the Positive Likelihood Ratio was 5.57%. The reproducibility of the assessment between the nurses and the trainees was excellent (Intraclass Correlation Coefficient = 0.99). For the authors, the score was useful to identify children at risk of deterioration, and its use by the nursing team during screening can be effective to identify a sick child[14].

A cross-sectional study of 518 patients aged 1 month to 18 years in Buenos Aires assessed the usefulness of PEWS in predicting clinical deterioration within 24 hours. The following criteria for deterioration within 24 hours were considered: interconsultation with the ICU staff, transfer to the ICU, one or more predetermined interventions (cardiopulmonary resuscitation maneuvers, two or more expansions with crystalloids or colloids, magnesium sulfate infusion in an asthmatic crisis, use of a high-flow nasal cannula, pleural drainage or death). The results showed that, using the cutoff point ≥ 4, PEWS had a sensitivity of 92.5%; Specificity of 88.3%, Positive Odds Ratio of 7.91, AUC of 0.94 (95% CI: 0.89-0.98) and Youden Index of 0.8. The authors considered the score useful for predicting clinical deterioration in hospitalized children[13].

A systematic review of the available evidence on the effectiveness of pediatric early warning scores in terms of predicting clinical deterioration in children analyzed 10 prominent studies, revealing that PEWS are applied extensively in varied settings, but their use still has limitations due to the variation of scores according to the settings. The positive results were related to the identification of deteriorating children, intervention by the multidisciplinary team, confidence in the

treatment and effectiveness in communication[16], since good and effective communication is necessary to ensure the safety, quality and continuity of care for pediatric patients[17].

Despite reports of the usefulness of PEWS, studies indicate that there is no evidence available on the best score to be used, which suggests that research should be carried out to assess the impacts of implementation, as well as results in resource-limited settings[9,16], where there may be a deficit of human resources and equipment[18,19].

In addition to the performance of PEWS in terms of recognizing clinical worsening, other criteria are pointed out in the literature as important for their choice and implementation, such as ease of use, practicality and understanding[1,4]. In the studies that validated the BPEWS-Br and the EPA, the mean time spent for application was very similar, ranging from 4 to 5 minutes[2,9,20], showing that the scores were easy to apply, which optimizes and supports their use.

In comparison with the BPEWS-Br and in addition to the clinical assessment criteria contemplated in the two instruments, the EPA guides a classification for severity, where the patient can be categorized into four stages: absence of signs of deterioration, mild signs, moderate signs and severe signs[8,9]. This categorization can facilitate the development of service flows that guide the team, an essential aspect for the development of alert systems.

From the aspects of validity and reliability, both the BPEWS-Br and the EPA can be implemented in similar contexts to support the assessment of deterioration by nurses in their practice and to assist clinical reasoning, since the application of scales involving diagnosis and prescription of nursing interventions is the exclusive responsibility of the nurse, since it involves the clinical assessment of the patient[21].

Regardless of the used system, researchers, professionals and managers of Brazilian health services need to wake up to the need to implement these tools in their context, given the evidence of their benefits in the care of hospitalized children.

The fact that this research was carried out in just one hospital stands out as a limitation of the study. In addition, the scarcity of publications on the validation of PEWS for Brazilian contexts limited the discussion of the results with national data, which raises the need for more scientific production on this topic, including multicenter studies.

CONCLUSION

The accuracy indicators of the BPEWS-Br and the EPA were similar and high, as was the agreement between the instruments. Accordingly, both scores can be recommended for use in Brazilian hospital contexts similar to the ones in this research.

In the national setting, considering aspects of validity, reliability, applicability and impact of PEWS on care and management indicators, there are still gaps in the evidence, which raises the need for further studies in this regard.

ACURÁCIA DE DOIS ESCORES PEDIÁTRICOS DE ALERTA PRECOCE DE DETERIORAÇÃO CLÍNICA NO CONTEXTO BRASILEIRO

RESUMO

Objetivo: comparar a acurácia e a reprodutibilidade do Escore Pediátrico de Alerta (EPA) e da versão brasileira do *Brighton Paediatric Early Warning Score* (*BPEWS*-Br) na identificação de sinais de deterioração clínica no contexto brasileiro. **Método:** estudo de acurácia de teste diagnóstico, realizado em um hospital materno-infantil de grande porte, com 240 crianças e adolescentes de 0 a 15 anos, de outubro de 2018 a maio de 2019. Os instrumentos para coleta foram o *BPEWS*, o EPA e os critérios da avaliação clínica primária da criança gravemente doente, recomendados pela *American Heart Association* como padrão de referência. Os dados foram analisados no *MedCalc® Statistical Software, version 20.007,* para estimar indicadores de acurácia e concordância entre os escores. **Resultados:** o EPA variou de 0 a 7 e o *BPEWS*-Br de 0 a 8. Considerando um escore ≥ 3, o EPA obteve prevalência de deterioração de 19,5%, o *BPEWS*-Br de 16,7% e o padrão de referência de 22,1%. As áreas sob as Curvas ROC do *BPEWS*-Br e do EPA se mostraram praticamente iguais, de 93,5% (IC: 90 – 97) e 93,6% (IC: 89,8 – 97,4), respectivamente, o que evidencia alta acurácia dos testes. O Índice *Kappa* entre os escores foi de 0,879 (IC 95%: 0,845 a 0,912), mostrando alta concordância. **Conclusão:** os indicadores de acurácia e reprodutibilidade do *BPEWS*-Br e do EPA foram elevados.

Palavras-chave: Escore de Alerta Precoce. Deterioração clínica. Enfermagem Pediátrica. Sensibilidade e Especificidade.

EXACTITUD DE DOS PUNTUACIONES PEDIÁTRICAS DE ALERTA TEMPRANA DE DETERIORO CLÍNICO EN EL CONTEXTO BRASILEÑO

RESUMEN

Objetivo: comparar la exactitud y reproducibilidad de la Puntuación Pediátrica de Alerta (*EPA*) y de la versión brasileña del *Brighton Paediatric Early Warning Score* (*BPEWS-Br*) en la identificación de señales de deterioro clínico en el contexto brasileño. **Método**: estudio de precisión de prueba diagnóstica, realizado en un hospital materno-infantil de gran tamaño, con 240 niños y adolescentes de 0 a 15 años, de octubre de 2018 a mayo de 2019. Los instrumentos para la recolección fueron el *BPEWS-Br*, el *EPA* y los criterios de la evaluación clínica primaria del niño gravemente enfermo, recomendados por la *American Heart Association* como estándar de referencia. Los datos fueron analizados en el *MedCalc® Statistical Software*, *version* 20.007, para estimar indicadores de exactitud y concordancia entre las puntuaciones. **Resultados**: el *EPA* varió de 0 a 7 y el *BPEWS-Br* de 0 a 8. Considerando una puntuación ≥ 3, el *EPA* obtuvo una prevalencia de deterioro del 19,5%, el *BPEWS-Br* del 16,7% y el estándar de referencia del 22,1%. Las áreas bajo las curvas ROC del *BPEWS-Br* y de la *EPA* se mostraron prácticamente iguales, de 93,5% (IC: 90 - 97) y 93,6% (IC: 89,8 - 97,4), respectivamente, lo que evidencia alta exactitud de las pruebas. El índice *Kappa* entre las puntuaciones fue de 0,879 (IC 95%: 0,845 a 0,912), demostrando alta concordancia. **Conclusión**: los indicadores de exactitud y reproducibilidad del *BPEWS-Br* y el *EPA* fueron elevados.

Palabras clave: Puntuación de Alerta Temprana. Deterioro clínico. Enfermería Pediátrica. Sensibilidad y Especificidad.

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