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INTEGRATIVE REVIEW ARTICLE

CLINICAL DETERIORATION IN HOSPITALIZED CHILDREN: INTEGRATIVE REVIEW OF A PEDIATRIC EARLY WARNING SCORE

DETERIORAÇÃO CLÍNICA EM CRIANÇAS HOSPITALIZADAS: REVISÃO INTEGRATIVA DE UM ESCORE PEDIÁTRICO DE ALERTA PRECOCE

DETERIORO CLÍNICO EN NIÑOS HOSPITALIZADOS: REVISIÓN INTEGRADORA DE UNA PUNTUACIÓN PEDIÁTRICA DE ALERTA TEMPRANO

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ABSTRACT

Objective: to review the literature with regard to using the Brighton Paediatric Early Warning Score as an instrument to identify signs of clinical deterioration in hospitalized children and possibilities of its application to the Brazilian context. ***Method***: integrative review, conducted in August 2015, with search in the databases MedLine and CINAHL, by using the terms "early warning score" AND "pediatric." ***Results***: the final sample consisted of 11 studies, whose variables under analysis were authors, country of origin, journal, year of publication, design, population, and main results. ***Conclusion***: the Brighton Paediatric Early Warning Score was used, in most studies, as a tool to measure warning signs of clinical deterioration in hospitalized children, and it may be regarded as a scoring option to be used in Brazil. The absence of works on the use of early warning scores in Brazil suggests the need for research on this theme. ***Descriptors*:** Patient Acuity; Alert; Hospitalized Child.

RESUMO

Objetivo: revisar a literatura quanto ao uso do Brighton Paediatric Early Warning Score como instrumento para identificar sinais de deterioração clínica em crianças hospitalizadas e possibilidades de sua aplicação no contexto brasileiro. ***Método***: revisão integrativa, realizada em agosto de 2015, com busca nas bases MedLine e CINAHL, utilizando os termos "early warning score" AND "pediatric". ***Resultados***: a amostra final foi de 11 estudos, cujas variáveis investigadas foram autores, país de origem, periódico, ano de publicação, delineamento, população e principais resultados. ***Conclusão***: o Brighton Paediatric Early Warning Score foi utilizado, pela maioria dos estudos, como ferramenta para medir sinais de alerta para deterioração clínica em crianças hospitalizadas, podendo ser considerada uma opção de escore para uso no Brasil. A falta de publicações sobre o uso de escores de alerta precoce no Brasil sugere a necessidade de realizar pesquisas acerca dessa temática. ***Descritores*:** Gravidade do Paciente; Alerta; Criança Hospitalizada.

RESUMEN

***Objetivo*:** revisar la literatura en relación con el uso del Brighton Paediatric Early Warning Score como un instrumento para identificar señales de deterioro clínico en niños hospitalizados y posibilidades de su aplicación en el contexto brasileño. ***Método*:** revisión integradora, llevada a cabo en agosto de 2015, con búsqueda en las bases de datos MedLine y CINAHL, mediante el uso de los términos "early warning score" AND "pediatric". ***Resultados*:** la muestra final consistió en 11 estudios, cuyas variables analisadas fueron autores, país de origen, revista, año de publicación, diseño, población y principales resultados. ***Conclusión*:** se utilizó el Brighton Paediatric Early Warning Score, en la mayoría de los estudios, como una herramienta para medir señales de alerta de deterioro clínico en niños hospitalizados, y esta puede ser considerada como una opción de puntuación para ser utilizada en Brasil. La ausencia de publicaciones sobre el uso de puntuaciones de alerta temprano en Brasil sugiere la necesidad de investigación acerca de este tema. ***Descriptores*:** Gravedad del Paciente; Alerta; Niño Hospitalizado.

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INTRODUCTION

Early recognition of the signs and symptoms of clinical deterioration in children is a key factor for survival and good prognosis. It is worth appreciating these signs during the anamnesis and the brief physical examination. Early treatment may prevent progression to worse current clinical status, shock, respiratory failure, or cardiopulmonary arrest (CPA).[1,2]

International studies have been published on the development of scores or scoring systems for early warning signs that may indicate clinical deterioration in hospitalized children, the so-called Pediatric Early Warning Score (PEWS). Their goal is early identification, at the bedside, of certain signs and warning the health team about the need of urgent care.[3-7]

Initially, the PEWS were built through changes in the scores to detect clinical deterioration in adults, published since 1997 and named as Early Warning Score (EWS).[8] Currently, there are many pediatric scores published in international databases, however, in Brazil there are no publications addressing the use of these scores in the pediatric population, and few studies on their use are found in adults.[9]

Among the PEWS types already published there is the Brighton Paediatric Early Warning Score (BPEWS), the first score aimed at the use in children, issued in 2005, by a nurse from the University of Brighton, in England.[3]

This review is a fragment of a Ph.D. thesis from the School of Nursing of the Federal University of Bahia (UFBA), under preparation, to verify the validity and reliability of the BPEWS to identify signs of clinical deterioration in hospitalized children.

The aim of this study is reviewing the literature as for the use of the BPEWS as an instrument to identify signs of clinical deterioration in hospitalized children and possibilities of its application in a Brazilian context.

METHOD

This is a descriptive study, an integrative literature review. Integrative reviews have the potential to build Nursing science. When properly carried out, they may introduce the state of the art, contribute to develop theories and direct application to the practice and policies.[10]

Integrative review is a comprehensive method that enables including theoretical and empirical literature, as well as studies with various methodological approaches (quantitative and qualitative). The studies included are systematically analyzed in relation to the objectives, materials, and methods, allowing the reader to analyze the pre-existing knowledge about the theme.[11,12]

This review followed six stages: choice and definition of the theme, literature search, establishing criteria to categorize the studies, analysis of the studies, interpretation of results, and presentation of the review.[11,12]

In the first stage we defined the guiding question: May the Brighton Paediatric Early Warning Score be regarded as an instrument to identify signs of warning about clinical deterioration in children?

The search was conducted in August 2015, in the databases MedLine and CINAHL, by using the following terms: “early warning score” AND “pediatric.” The survey adopted the advanced search method, following a flowchart (Figure 1). We found 91 studies (40 in the MedLine through Pubmed, 32 in the MedLine through the VHL, and 19 in the CINAHL). After excluding 47 repeated studies, there remained 44 studies for reading and evaluation. They underwent the following inclusion criteria: studies available in full text, in the English, Portuguese, and Spanish languages, year of publication (2005 to 2015), whose abstract describe the use of pediatric scores of early warning in their design. The exclusion criteria were: studies available only as abstracts, review, reflection, monograph, thesis, dissertation, book chapter, manual, leaflet, not addressing the subject, and study addressing the subject, but without focusing on the use of pediatric scores of early warning in their design.

The abstracts were analyzed by two independent reviewers. The studies whose abstracts raised doubts concerning the use of pediatric scores of early warning in their design were read in full text. The studies with no agreement as for the inclusion in this review were analyzed by a third reviewer.

After applying the inclusion and exclusion criteria, 20 studies were excluded and 24 remained. Out of the latter, 11 did not use the BPEWS as a warning score. Initially, 13 studies using the BPEWS in original or modified/adapted versions as a tool to recognize warning signs of clinical deterioration in hospitalized children were selected. Out of these 13 selected studies, 2 were also excluded, which used the BPEWS as a basis for building other tools, by using other names. Thus, the final sample consisted of 11 studies.

After defining the final sample, the extraction, organization, and summarization of information contained in the articles were carried out. In the 11 studies selected, we investigated: authors, country of origin, journal, year of publication, objective, population, design, and main results.

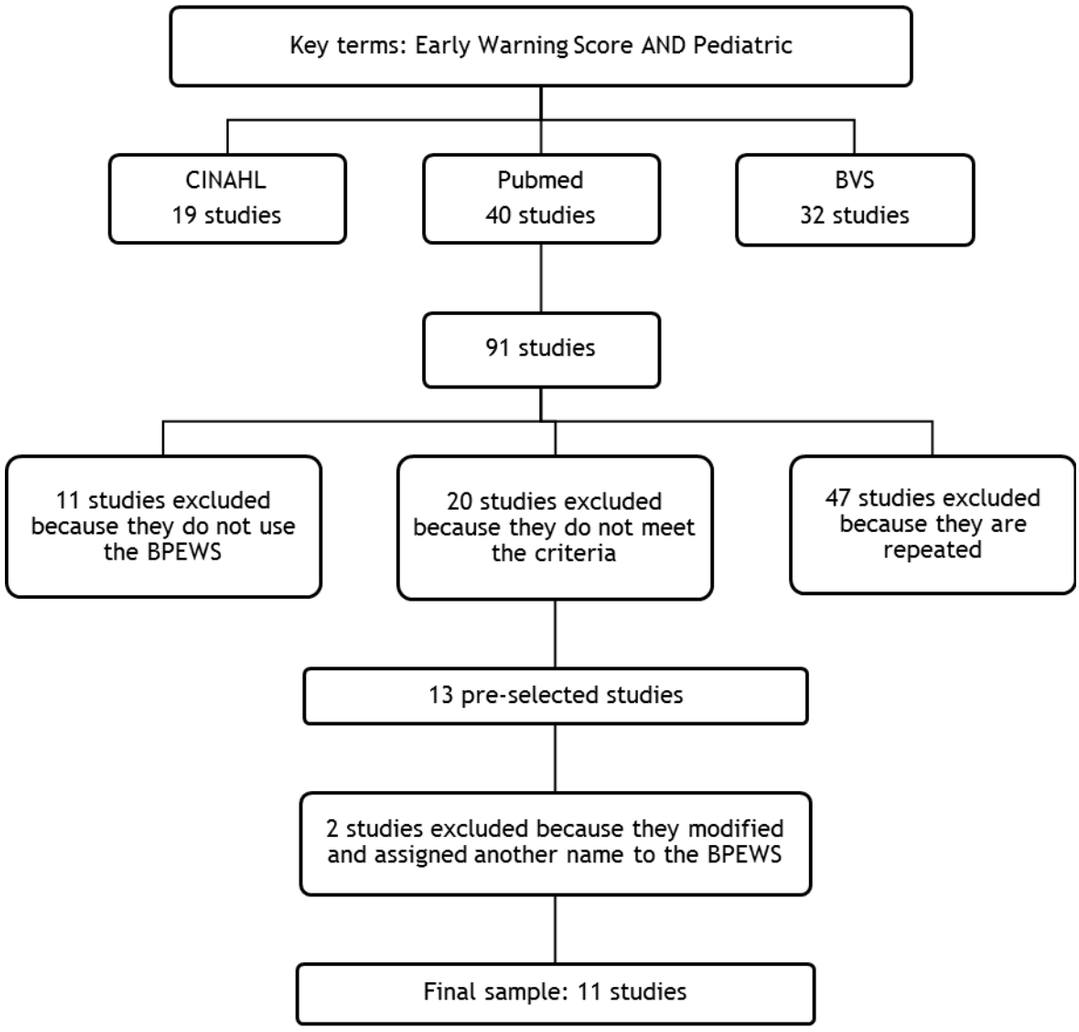

Figure 1. Flowchart of the review search. Salvador, 2015.

RESULTS

The studies in this review are displayed in Figure 2.

Author/country/year	Objetive	Design	Main results
Monaghan A.[3] England 2005	Describe the development of an early warning score (BPEWS) to help detecting the risk of clinical deterioration in children.	Pilot descriptive study with 30 hospitalized children that evaluated the BPEWS scores as for the actions taken and the results.	96% of the patients were seen within 15 minutes of applying the BPEWS and they required intervention, 83% improved after the intervention, and 17% were admitted to the intensive care unit (ICU).
Tucker KM et al.[13] USA 2009	Evaluate the use of BPEWS for detecting clinical deterioration in hospitalized children.	Prospective study with 2,979 patients aged between 0 and 22 years for 12 months to verify the validity and reliability of the BPEWS for detecting clinical deterioration in hospitalized children. Transfer to the ICU was determined as an option of choice to determine clinical deterioration. Inter-observers reliability was marked in 55 patients.	Among the patients, 73.2% had a BPEWS ≤ 2. A BPEWS 3 showed a sensitivity of 90.2%, a specificity of 74.4%, a positive predictive value (PPV) of 5.8% and a negative predictive value (NPV) of 99.8%. A BPEWS 9 showed a sensitivity of 7.8%, a specificity of 99.9%, a PPV of 80%, and a NPV of 98.4%. The area under the ROC curve was 0.89 (95% CI: 0.84 to 0.94). The intraclass correlation coefficient (ICC) calculated to measure interobservers

			reliability was 0.92.
Akre M et al.[14] USA 2010	Evaluate the sensitivity of the BPEWS as an early indicator of deterioration leading to a call to the rapid response team (RRT) or blue code (BC).	Retrospective study using data from the medical records of 186 patients aged between 0 and 21 years. Out of them, 170 required a call to the RRT and 16 a BC. The sensitivity of the BPEWS was tested in this population for predicting clinical deterioration 24 hours before calling the RRT and BC.	The score sensitivity for predicting was 85.5% for patients with a BPEWS ≥ 4 before calling the RRT or BC. Among patients who experienced calling the RRT, 23.5% were transferred to the ICU and 91% received significant medical intervention: 37.1% oxygen, 27.1% nebulization, 21.1% aspiration, 17.6% heart monitoring, and 21.1% blood gas.
Randhawa S et al.[15] USA 2011	Describe the process and results of the implementation and maintenance of using the BPEWS in inpatient units.	Descriptive study using a methodology based on cycles of change for performance improvement: 1st cycle with 15 beds of cardiology and nephrology, 2nd cycle with 39 beds of general clinic, and 3rd cycle with 136 beds of acute care.	Using the BPEWS reduced CPA by 37% in the 1st cycle and by 25% in the 2nd cycle. In the 3rd cycle, CPA was reduced by 23.4%. The calls to the evaluation and screening team of the ICUs were reduced by 19.4%.
Skaletzky SM et al.[16] USA 2012	Validate a modified version of the BPEWS for evaluation of children at risk of clinical deterioration in nursing wards.	Retrospective case-control study over a 30-month period with data from 100 case patients records (transferred from the medical-surgical ward to the ICU) and 250 controls (not transferred to the ICU) aged between 0 and 14 years. The maximum score in the modified BPEWS was calculated for each case 48 hours before transfer to the ICU and for each control 48 hours after admission to the hospital. The transfer to the ICU determined clinical deterioration.	The length of hospital stay was significantly higher in cases (cases: 18.09 ± 32 vs 3.93 ± 2.9 days, $p < 0.001$) The maximum score in the BPEWS was significantly higher in cases (cases: 2.95 ± 1.5 vs controls: 1.4 ± 0.8, $p < 0.0001$). The maximum score in the BPEWS and transfer to the ICU showed an area under the ROC curve of 0.81 (95% CI: 0.75-.86). The sensitivity and specificity of the modified BPEWS for transfer to the ICU were 62% and 89%, respectively.
Bradman K et al.[17] Australia 2012	Compare the nurse screening (NS), the screening categories 1, 2, and 3, the tool PRISA (Pediatric Risk of Admission Score), the tool PRISA II (Pediatric Risk of Admission Score II), and the BPEWS as for the accuracy in predicting admission to the hospital through the emergency.	Prospective observational study with 946 children conducted for a week. The admission predictions by the NS were compared to the screening categories 1, 2, and 3, with a PEWS ≥ 4, with a PRISA ≥ 9, and a PRISA II ≥ 2.	Out of the hospitalized patients, NS showed an accuracy of 87.7% in predicting admission, followed by BPEWS ≥ 4 and the screening categories 1, 2, and 3, both with 82.9%, PRISA ≥ 9, with 80.1%, and PRISA II ≥ 2, with 79.7%.
Brady PW et al.[18] USA 2012	Identify the impact of a care system to identify, mitigate, and phase risk in reducing unsafe transfers to the ICU in patients with unrecognized clinical deterioration.	Time series observational study. Unsafe events were defined as intubation, inotropic, or ≥ 3 fluid bolus within 1 hour before or after admission to the ICU. The BPEWS ≥ 5 was included in the system as a risk factor for deterioration.	The rate of unsafe transfers to the ICU/10,000 days of hospitalization outside the ICU was significantly reduced from 4.4 to 2.4 after the new care system.
Solevåg AL et al.[19] Norway 2013	Analyze the relationship between a modified version of the BPEWS and certain characteristics of	Retrospective study with data from the medical records of 761 patients aged between 0 and 18 years. Children with	Out of the 761 patients, 16.2% had a BPEWS ≥ 3 and 83.8% had a BPEWS ≤ 2. Patients with a BPEWS ≥ 3 underwent more fluid resuscitation, use

	patients in a pediatric service.	BPEWS ≥ 3 were compared to children with BPEWS ≤ 2 in relation to age, diagnosis, and severity indicators.	of intravenous antibiotics, oxygen, and transfers to more complex units than patients with a BPEWS ≤ 2.
Seiger N et al.[20] Netherlands 2013	Compare the validity of 10 different PEWS for predicting admission to the ICU and hospitalization through getting into a pediatric emergency department.	Cohort study, with 17,943 patients < 16 years admitted to the emergence room of a university hospital between 2009 and 2012. The BPEWS was one of the most tested scores.	Out of the 10 PEWS tested, sensitivity ranged from 61.3% to 94.4% and specificity from 25.2% to 86.7% for admission to the ICU. As for hospitalization, sensitivity ranged from 36.4% to 85.7% and specificity from 27.1% to 90.5%.
Zhai H et al.[21] USA 2014	Develop and evaluate the performance of an automated algorithm to predict the need for transfer to the ICU within 24 hours of admission and compare the effectiveness of this algorithm to the scores Bedside PEWS and Monaghan's PEWS (another name for BPEWS).	A retrospective case-control study with 7,298 patients, with 526 cases of patients admitted to the ICU within 24 hours of admission and 6,772 controls of patients who had never been transferred to the ICU. In the new algorithm, 29 variables were used in a logistic regression and the performance was compared to the Bedside PEWS and Monaghan's PEWS.	The new algorithm is more sensitive (0.849, 95% CI, 0.753-0.945), specificity (0.859, 95% CI, 0.850-0.868), and area under the ROC curve (0.912, 95% CI, 0.905-0.919) when compared to the Bedside PEWS (sensitivity 0.736, 95% IC, 0.597-0.847, specificity 0.717, 95% CI, 0.706-0.728, and area under the ROC curve 0.816, 95% CI, 0.806-0.826), and Monaghan's PEWS (sensitivity 0.684, 95% CI, 0.434-0.874, specificity 0.816, 95% CI, 0.802-0.829, and area under the ROC curve 0.744, 95% CI, 0.728-0.759).
Gold DL et al.[22] USA 2014	Verify whether the Monaghan PEWS assigned to patients in the emergency department can predict the need for hospitalization in the ICU or clinical deterioration in hospitalized patients.	Prospective observational study with a sample of 12,306 patients aged between 0 and 21 years. The Monaghan PEWS was defined in the initial evaluation in the emergency (P0) and at the admission (P1).	Out of the 12,306 patients, 10.6% were admitted from the emergency to the ICU and 89.4% to an inpatient unit. The BPEWS in P0 and P1 were significantly higher for the ICU group (P0 = 2.8 ± 2.4; P1 = 3.2 ± 2.4; $p < 0.0001$) than the inpatient unit (P0 = 0, 7 ± 1.2; P1 = 0.5 ± 0.9; $p < 0.0001$). The ICC had 0.91.

Figure 2. Studies selected for the review according to author, country of origin, year of publication, objective, design, and main results. Salvador, 2014.

The first study presented in this review describes the development and initial application of the BPEWS (Figure 3). The instrument is based on three evaluation components: neurological status, cardiovascular status, and respiratory status. Its score may range from 0 to 13 points, and since 3 points, the higher the score, the greater the risk of deterioration, triggering a sequence of actions that guide the nurse's actions.

The team's experience with the system was positive, since 80% out of the 33 employees of the wards reported that the BPEWS improved performance in recognizing a child at risk of deterioration. The author stressed the importance of verifying the validity and reliability of the score, as well as the intention to test the reliability of the instrument assessors.[3]

	0	1	2	3	Score
Behavior	Playing / Appropriate	Sleeping	Irritable	Lethargic/ confused Reduced response to pain	
Cardiovascular	Pink or capillary refill 1-2 seconds	Pale or capillary refill 3 seconds	Grey or capillary refill 4 seconds Tachycardia of 20 above normal rate	Grey and mottled or capillary refill 5 seconds or above. Tachycardia of 30 above normal rate or bradycardia	
Respiratory	Within normal parameters, no recession or tracheal tug	> 10 above normal parameters, using accessory muscles, 30+ % Fi02 or 4+ litres/min	> 20 above normal parameters, recessing, tracheal tug, 40+ % Fi02 or 6+ litres/min	5 below normal parameters with sternal recession, tracheal tug or grunting, 50% Fi02 or 8 + litres/min	
Score 2 extra for 1/4 hourly nebulisers or persistent vomiting following surgery					

Figura 3. Brighton Paediatric Early Warning Score.
Fonte: Monaghan.[3]

The second study of this review provided the first analysis of validity and reliability of the BPEWS, noting that the tool has produced valid and reliable data with a good accuracy. It has found that for a BPEWS 3 there was a need for further intervention, besides, high scores were predictive of patients who required transfer to the pediatric ICU. Transfer to the ICU as a standard of choice for clinical deterioration was pointed out as a limitation of the study, and it was suggested that the BPEWS could be more sensitive and specific than reported and further research on other standards of choice for clinical deterioration might be justified. Furthermore, additional studies evaluating the impact of the tool BPEWS on clinical results might contribute to the medical and pediatric nursing literature.[13]

The third study in this review showed a weakness of registers in medical records provided by nursing, however, it claimed that the BPEWS was regarded as a sensitive instrument to warn the team to adjust its care plan and possibly avoid calling the rapid response team (RRT) or a blue code (BC), as it provided a previous notice from 30 minutes to 11 hours and 36 minutes before the events.[14]

The fourth study adopted the BPEWS by regarding it as a valuable tool, reliable, and easy to adapt to the nurse's workflow. A methodology based on change cycles known as Plan-Do-Check-Act (PDCA) was used. The results were encouraging in reducing CPA and improving nurses' skills in detecting early signs of clinical deterioration, providing patient care with no need to call the ICU team.[15]

The fifth study, which used a modified version of the BPEWS, showed in its results low sensitivity, high specificity, and high accuracy of the tool for transfer to the ICU. The limitations included the retrospective design, due to failures in nursing records, and the various interpretations in the neurological component of the BPEWS. It was concluded that the modified version of the BPEWS may help identifying patients in the wards at risk of deterioration and prevent adverse events.[16]

The sixth study showed that nurses' screening, professionals trained and experienced in pediatrics and emergency, was the most accurate indicator concerning the need to admit emergency patients to the hospital than the tools BPEWS, PRISA, PRISA II, and the screening categories 1, 2, and 3. The most important limitation cited in the study were errors in the records.[17]

The seventh study showed that the care system, whose BPEWS ≥ 5 was included as a risk factor for deterioration, developed and tested to identify and minimize a patient's risk, was associated with a significant reduction by almost 50% in unsafe transfers and severe safety events among hospitalized patients.[18]

In the eighth study, younger age and diagnostic groups with lower airways and cardiovascular disorders were associated with BPEWS ≥ 3. These patients required more care, such as fluid replacement and oxygen, than patients with scores between 0 and 2. Errors in the records may be identified as a limitation. The conclusion pointed out that patients with a score ≥ 3 should be carefully monitored to prevent further deterioration.[19]

In the ninth study, none of the 10 scores or scoring systems tested showed high sensitivity and specificity for predicting ICU admission or hospitalization. The weighted aggregate

systems, such as the BPEWS, performed better in identifying the risk of clinical deterioration than the triggering systems. Besides, the BPEWS had less time consuming evaluation and it excludes blood pressure, a key information difficult to achieve in a standardized manner in emergency units with excessive demand.[20]

In the tenth study, among the 29 variables used in the final logistic regression model for the new algorithm, 23 were significantly associated with transfer to the PICU ($p < 0.05$). Some of the limitations identified in this study were data loss (leading cause of incorrect prediction of transfer) and transfer to the ICU as an outcome (transfer does not always depend on patient's factors, the availability of beds, for instance, is also a determining factor). However, the conclusion was that the new algorithm reached greater sensitivity, specificity, and accuracy than the Bedside PEWS and the Monaghan's PEWS.[21]

The eleventh and final study in this review showed that the Monaghan PEWS implemented to evaluate patients in the emergency unit showed excellent data capture and high reliability among assessor nurses. Patients with high scores were more likely to be admitted from the emergency to the ICU or transferred from the floor to the ICU. Although there may be reasons to consider using the score in emergencies, the tool does not have enough features to be used independently in these units. The authors also pointed out that the Monaghan PEWS was chosen because it is already used in the institution, it has already been validated and applied quickly and accurately by nurses who deal with the burden of emergency care.[22]

DISCUSSION

The Pediatric Early Warning Scores have been developed over the last 10 years, in order to identify signs of clinical deterioration in hospitalized children through the application of warning criteria or scores. These early warning scoring systems indicate to the team those patients at risk for severe adverse events through periodic observation of clinical signs and pre-determined criteria that highlight urgent care.[23] The PEWS should be a part of a set of actions to provide care, on a quick and early basis, to patients at risk for clinical deterioration.

The Brighton Paediatric Early Warning Score was the first instrument published to assist in the early identification of warning signs that suggest potential risk of clinical deterioration in children. Through it, other pediatric scoring systems or early warning criteria have been built and/or modified and adapted, such as the Pediatric Early Warning System[4], Pediatric Early Warning Tool[5], Bedside Paediatric Early Warning System[6], among others. However, there is no consensus in the literature about what is the score considered as the gold standard in identifying clinical signs of deterioration in children, it is necessary that each service evaluates the tools available and choose the one that best suits its need and reality.

The studies presented in this review bring BPEWS or Monaghan PEWS as a tool available in the international scientific literature, able to improve the results, validated and reliable to identify warning signs of clinical deterioration in children in the hospital environment.

According to the author of the BPEWS, the score might generate immediate action and, through a standard set of observations, the tool might provide an objective assessment, avoiding factors that could affect the assessment, in addition to long justifications on the phone to request early medical evaluation.[3] This is a reality experienced in the wards of many Brazilian pediatric hospitals, where hospitalized children spend most of their time undergoing nursing care and the physician is called in situations that nursing deems as necessary, considering the demand of other units in the hospital.

Although some studies show limitations of the BPEWS when compared to rather sophisticated assessments, the score proved to be easy to apply and user-friendly, something which seems to be feasible for using in Brazil, since many pediatric hospitals, mainly in the public initiative, lack monitoring equipment at the bedside, have an insufficient number of intensive care beds, in addition to few nursing professionals in face of the high demand for care, often not allowing a rather careful patient assessment. The use of a tool with easy and quick applicability, with no need for sophisticated technologies, such as the BPEWS, might improve this situation.

A tool like the BPEWS could be adopted in hospital services in Brazil to help pediatric nursing in the daily assessment of patients in emergency care and inpatient units, in order to, along with a multidisciplinary team, recognize and act on an early basis in risk situations, prevent complications, avoid the need for hospitalization in more complex units, and thus improve the results.

This article is limited to a review study. Thus, more robust studies with application of the BPEWS in Brazilian contexts need to be conducted to test its validity and reliability in identifying warning signs of clinical deterioration in hospitalized children.

CONCLUSION

Most authors who used the BPEWS, as well as its author, regarded this instrument as capable of measuring warning signs in children at risk for clinical deterioration by means of the scoring system adopted. Among the tools built and validated for this purpose, the BPEWS can be regarded as involving low complexity, short time, and wider feasibility of application, since its use is quick, based on the assessment and identification of only three components, there is no need for monitoring equipment.

It is noteworthy that other warning scores have been developed with the same purposes, something which raises the need for studies comparing the validity and reliability of these instruments to evaluate what best fits the reality of each service.

In Brazil, the absence of works addressing the use of pediatric early warning scores suggests that research on this theme are conducted to adapt existing instruments, validate them, or build new tools that help nursing in the early identification of clinical deterioration in hospitalized children, the prevention and action in associate complications, improving the results.

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