Journal of Pediatric Nursing 63 (2022) 90–95

Contents lists available at ScienceDirect

Journal of Pediatric Nursing

journal homepage: www.pediatricnursing.org

Modification of a children's hospital pediatric early warning score (EWS): An evaluation of inter-rater reliability, nurses' critical thinking and perceptions of the tool

Adrienne S. Schleisman, BSN, RN, CPN [a,*], Meghan Potthoff, PhD, APRN-NP, PPCNP-BC, CPNP-AC [b], Katharine Schjodt, MSN, APRN-PCNS-BC, CPN, CPHON [c]

[a] Creighton University, Children's Hospital & Medical Center, Omaha, NE 68124, United States of America
[b] Creighton University, 2500 California Plaza, Omaha, NE 68178, United States of America
[c] Children's Hospital & Medical Center, 8200 Dodge Street, Omaha, NE 68114, United States of America

ARTICLE INFO

Article history:
Received 26 April 2021
Revised 2 August 2021
Accepted 22 September 2021

Keywords:
Pediatric early warning score (EWS)
Children's hospital early warning system (CHEWS)
Inter-rater reliability

ABSTRACT

Pediatric early warning scores (EWS) have been utilized to assist the identification of children at risk for clinically decompensating, experiencing a cardiac or respiratory arrest, or requiring a transfer to a higher level of care. Although their use is widespread, little consistency exists between tools and research evaluating the effectiveness of these tools is lacking. This quasi-experimental project evaluated twenty-five medical-surgical staff nurses' use and perceptions as well as the inter-rater reliability of a newly modified pediatric EWS tool at a free standing, academic Midwestern pediatric hospital. The tool was modified utilizing existing literature and an interdisciplinary team's expertise. Five fictionalized patients, presented in case studies, were developed and nurses were asked to score these patients using the newly modified tool with rationale. Inter-rater reliability was assessed utilizing Fleiss' Kappa and qualitative questionnaire data was analyzed for emerging themes. Overall, Fleiss' Kappa showed that there was moderate agreement between the nurses' judgments and scoring, with scores primarily differing due to the difficulty level of each case study. Nurses' responses to a questionnaire indicated differing levels of comfort identifying and managing children that present with mid-range total scores as opposed to those who scored in the lower or higher ranges. This project's findings highlight nurses' concerns that an objective tool may not accurately describe a subjective assessment. The results of this project indicated that use of this tool, with some modifications to address nursing concerns, may help to identify clinically decompensating pediatric patients being treated on medical-surgical units.

Background

Like adults, children need inpatient hospitalization to address a multitude of acute and chronic illnesses. Approximately 5.9 million children were hospitalized in the United States in 2012 (Witt et al., 2014). While the rate of pediatric admissions has declined over the past few years (Bucholz et al., 2019; Witt et al., 2014), children that still require admission are more likely to have a chronic condition or require complex management (Bucholz et al., 2019).

Despite an overall higher patient acuity, many children are successfully treated outside of pediatric intensive care units (PICUs). However, initial admission to a general medicine floor does not preclude a child from unexpectedly decompensating, experiencing a cardiac or respiratory arrest, or require a transfer to a higher level of care (Krmpotic & Lobos, 2013; Mansel et al., 2018). Unfortunately, this is not an uncommon occurrence and it may result from inappropriate admission triaging and clinical status changes (Mansel et al., 2018; Miles et al., 2016; Nadeau et al., 2019). Ultimately, these events negatively impact patients' quality of life, lengthen hospital stays, increase mortality rates, and incur additional healthcare costs (Hussain et al., 2019). While the rate of these incidents may vary from institution to institution, this problem is pervasive across most pediatric inpatient facilities.

It is estimated that there are approximately 15,200 incidents of in-hospital cardiac arrests in pediatric patients per year (Holmberg et al., 2019). Recent studies estimate that preliminary survival rate may be close to 81.2% of children (Girotra et al., 2013). Unfortunately, survival rates to hospital discharge are much lower, approximately 27–34.8% (Girotra et al., 2013; Nadkarni et al., 2006).

* Corresponding author.
E-mail addresses: adrienneschleisman@gmail.com (A.S. Schleisman), meghanpotthoff@creighton.edu (M. Potthoff), kschjodt@ChildrensOmaha.org (K. Schjodt)

https://doi.org/10.1016/j.pedn.2021.09.023
0882-5963/

The rate of unplanned PICU transfers may be as rare as cardiac arrests rates. Less than 1% of all pediatric admissions result in an unplanned PICU transfer (Reese et al., 2015). Yet, researchers determined that 36% of these events were preventable and likely a result of medical errors (Miles et al., 2016; Reese et al., 2015). Interestingly, it is reported that only 25% of these transfers occurred after a rapid response team was activated. Additionally, mortality rates were much higher for those pediatric patients that were transferred to the PICU from a general medical unit (3.8%) as opposed to other patient care areas (1.4%) (Humphreys & Totapally, 2016).

Although these incidences are relatively uncommon, they have profound financial consequences. The financial burden that results after pediatric patients experience a clinical deterioration event, is approximately $100,000 of additional healthcare services as compared with children who did not (Bonafide, Localio, Song, et al., 2014).

Due to the extensive nature of this problem, unplanned, emergent pediatric transfers and codes outside of the intensive care units are classified as a serious safety event (Brady et al., 2013; Hoppes et al., 2012). As a result, numerous healthcare organizations, including Children's Hospitals' Solutions for Patient Safety, Children's Hospital Association, and the Institute for Healthcare Improvement (IHI), have partnered together in order to reduce the rates of unplanned, emergent pediatric transfers and codes outside of the intensive care units (Children's Hospitals' Solutions for Patient Safety, 2020a, 2020b; IHI, 2020).

As such, numerous initiatives, including the development and implementation of early warning scores (EWS) and rapid response teams, have been created and utilized across multiple institutions. The thought behind these interventions is to better and quickly identify children who are decompensating and begin appropriate management strategies to prevent them from deteriorating further, experiencing a cardiac or respiratory arrest, or require transfer to the PICU (Lambert et al., 2017; Murray et al., 2015). Fortunately, the implementation of these types of tools has shown to decrease rates of cardiac and respiratory arrests as well as improve mortality rates (Hayes et al., 2012; Maharaj et al., 2015).

Although many children's hospitals utilize these systems, there is little consistency between each institutions' early warning systems. Variations include differences in EWS as well as the presence, activation, and use of rapid response teams. Additionally, unlike in their adult counterparts, evidential support for each pediatric EWS varies widely and may be contradictory (Lambert et al., 2017; Murray et al., 2015). Differences in a hospital's culture as well as a lack of understanding of the system's purpose and how to utilize it appropriately may negatively affect a provider's support and application of the selected EWS (Cassidy et al., 2019; Jensen et al., 2018). Arguably, this makes it difficult to determine the best evidence-based system and employ its subsequent components within a pediatric hospital.

EBP purpose

The purpose of this project was to modify the current pediatric EWS being utilized at a free-standing, Midwestern children's hospital. The aims of this project were to adjust the existing pediatric EWS' parameters and language utilizing literature and interdisciplinary providers' input and expertise, evaluate the inter-rater reliability of the newly modified tool, and provide recommendations for further research and implementation.

Literature synthesis

Although numerous differences exist between pediatric EWS, most researchers agree that implementing and utilizing a formally validated, effective system within an institution has the potential to enhance patient safety (Chapman et al., 2017; Lambert et al., 2017; Murray et al., 2015; Trubey et al., 2019). However, in order to be effective, each system must incorporate both an assessment tool and rapid response team (Chapman et al., 2017). When used in conjunction with one another, many systems have seen decreased unplanned transfers to the PICU and positively impacted mortality rates as well as decreased incidences of cardiac and respiratory arrests (Agulnik et al., 2016; Bonafide, Localio, Roberts, et al., 2014; McLellan et al., 2014; McLellan et al., 2017; Parshuram et al., 2009; Parshuram et al., 2018). Additionally, changes in patient scores may help to improve a provider's ability to recognize a deteriorating patient (Bonafide, Localio, Roberts, et al., 2014). Further, they have the potential to increase the time providers have to identify and intervene before a child clinically decompensates and requires an escalation in their care (McLellan et al., 2014). Improvement in any or all of these areas may dramatically improve a child's clinical outcomes.

Yet, the presence of an EWS is not enough to ensure its success. Organizations must be able to recognize and evaluate barriers that prevent their universal adoption. Failure to do so may result in a previously validated system becoming misused or underutilized. Therefore, efforts should not only incorporate interventions to mitigate against these factors, but also promote the system's positive elements, or its enablers, in order to ensure widespread acceptance and utilization (Cassidy et al., 2019; Jensen et al., 2018).

EBP conceptual framework

The ACE Star Model of Knowledge Transformation is exceptionally useful for individuals wishing to incorporate researchers' important findings into process changes and quality improvement projects as it seeks to simplify the breadth of research that is available. This simplification allows those championing change to translate complex findings into straightforward recommendations and interventions. This is accomplished through the completion of five steps, which are represented by a point on a star. Stages include discovery, evidence summary, translation, integration, and evaluation (Stevens, 2013). As such, this framework was selected and utilized to guide this project.

Methods

Design

This quality improvement project was a quasi-experimental mixed methods design in which medical-surgical staff nurses' use and perceptions of a pediatric EWS at a Midwestern pediatric hospital were examined.This project was completed at a free-standing, academic Midwestern children's hospital.

Sample

This project's participants included associate and bachelor's degree prepared registered nurses ($n = 25$) who were either part-time or full-time employees who provided direct patient care on medical-surgical units. Participants were stratified based on their years of practice as a pediatric nurse. Nurses were recruited to complete the case studies and subsequent questionnaire via emails and staff meetings. Follow-up emails were sent by the unit managers to encourage continued participation in the study throughout the data collection phase.

Procedures

To begin, the institution's existing pediatric EWS was modified in accordance with best practices identified in the literature and clinical expertise by an interdisciplinary healthcare team, which included staff nurses, clinical nurse educators, nurse practitioners, and physicians. Once revised by the project lead utilizing literature, the new tool was presented to an interdisciplinary panel to evaluate its content validity. Once completed, the final version was presented to the same panel members to receive final approval.

Table 1
Nurse participant demographics.

$N = 25$	
Unit	Frequency (%)
4 Med/Surg	6 (24%)
5 Med/Surg	2 (8%)
6 Med/Surg	17 (68%)
Years of Experience	
<1 Year	2 (8%)
1–5 Years	14 (56%)
6–10 Years	7 (28%)
11+	2 (8%)

Table 2
Fleiss' Kappa.

Case Study	Fleiss Multirater Kappa (95% CI)
1	0.548 (0.547, 0.550)
2	0.427 (0.426, 0.428)
3	0.768 (0.766, 0.769)
4	0.504 (0.503, 0.505)
5	0.075 (0.073, 0.076)

Five scenarios were developed in conjunction with the clinical simulation director to be utilized as the case studies and designed to encompass the range of all possible scores, an answer key was developed, and reviewed by the clinical simulation director and the faculty chair. Once approval from both parties was obtained, the case studies were presented to the interdisciplinary team members. Minor modifications were made upon request of the interdisciplinary team members to the case studies prior to commencing data collection.

Staff nurses were then instructed to examine each of these five cases and independently score each fictionalized patient on the newly modified pediatric EWS tool. Each case was evaluated 25 times and the tool was provided for each nurse. At the conclusion of the scoring process for each case, nurses were asked qualitative questions exploring their critical thinking as it relates to the PEWS and detailing their responses to the patient's score. An operational definition of "critical thinking" utilized in this project was the "process to collect, evaluate, and analyze objective and subjective patient data to inform their decision making in patient care."

Institutional review board approval

The project was deemed quality improvement, non-human subject research, by both University of Nebraska Medical Center IRB and Creighton University IRB. There were no conflicts of interested identified by the authors of this QI project.

Statistical analysis

After the conclusion of the data collection process, each case was independently evaluated for its score's consistency and range as well as the nurses' critical thinking process in order to evaluate the inter-rater reliability of the modified tool and its application to clinical practice. Data were collected and coded in an excel spreadsheet by the researcher and a professional statistician was consulted to assist with the analysis of inter-rater reliability using Fleiss' kappa (Laerd Statistics, 2019). Data from the qualitative questions on nurses' responses to the patient scores were themed independently by the project lead and faculty and then reviewed together for consistency of emerging themes.

Findings

Twenty-five registered nurses with varying levels of experience employed across three medical-surgical units completed the case studies and answered the subsequent questionnaire. Of these nurses, a majority that completed the study indicated they had been a nurse for 1–5 years (56%) and employed on a unit that primarily cared for children with medical-surgical diagnoses, hematologic-oncologic processes, mental health crises, and endocrine disorders.Demographic information is presented in Table 1.

Inter-rater reliability

Overall, Fleiss' kappa showed that there was moderate agreement between the nurses' judgments for each scenario, excluding the highest (Case Study 3, $k = 0.768$) and the lowest (Case Study 5, $k = 0.075$) (Laerd Statistics, 2019). Values of kappa ranged from 0.075 to 0.768 (Table 2). Case 5 which reflected the lowest multirater agreement (Fleiss Kappa = 0.75) was a clinical scenario where a patient has abnormal clinical findings as their baseline. This is likely reflective of nurses not accounting for the baseline expectations of the patient and scoring off of a typical "normal".

Score consistency

Additionally, participants' scores were analyzed and compared with the "correct" answers, as determined during the case studies' development by the interdisciplinary team. Results are presented below in Table 3. Most nurses agreed with the "answer key" created by the interdisciplinary team on whether or not they were concerned about a patient's clinical status. There was however inconsistency with the answer key when looking at some of the PEWS subcategories that make up the total score. For example, with Case Study 2 only one third of the participants scored the patient's neurologic status to match the answer key. Similarly, only 24% scored the family concern for Case Study 4 in agreement with the answer key. Total PEWS score agreement with the answer key was low for Case Study 1 with only 28% in agreement with the interdisciplinary teams scoring of that case.

The fact that there is substantial variability around agreement for cases suggests that in addition to inter-rater variability there is substantial variability with respect to the tool's use in different scenarios.

Questionnaire response data

While inter-rater reliability and scoring consistency varied, nurses' responses to the questionnaire indicated a high level of agreement among the nurses' rationale for a concerning or non-concerning clinical presentation, necessary nursing interventions (i.e. increasing bedside monitoring, notification of a healthcare provider, administration of

Table 3
Percent of Correct Responses by Question and Case.

	Behavior/Neurologic	Cardiovascular	Respiratory	Staff Concern	Family Concern	'Total'	Nurse Participant is Concerned
Case Study 1	96%	100%	76%	28%	80%	28%	84%
Case Study 2	36%	68%	64%	100%	100%	44%	100%
Case Study 3	96%	80%	84%	100%	100%	72%	100%
Case Study 4	96%	88%	28%	84%	24%	56%	12%
Case Study 5	96%	72%	88%	100%	100%	72%	0%

medications, etc.), and expected clinical outcomes. Themes of the nurses' responses from the questionnaire are summarized below in Table 4.

Case Study 1

Case study one centered around a pre-school aged child with leukemia being admitted to a medical-surgical unit after presenting the emergency department with a fever. A majority of nurses (84%) indicated that they were concerned with the patient's clinical status. The most commonly recommended interventions included increasing patient monitoring, notification of a healthcare provider, administering medications, and recommending further interventions.

Case Study 2

This case study discussed the clinical status of a 4 month-old male with respiratory syncytial virus (RSV) being managed on heated high flow (HHF) and worsening respiratory status. One-hundred percent of nurse participants agreed that this patient was at high risk for clinical decompensation and exhibited concerning signs and symptoms. As a result, many responses to the questionnaire indicated a need to notify a provider and respiratory therapist (RT) as well as identified further interventions and the need for increased monitoring.

Case Study 3

Similarly, all participants concurred that the third fictionalized patient, a teenager presenting to a medical-surgical unit in diabetic ketoacidosis (DKA) with altered mental status, was at high risk for clinical deterioration. Responses to the questionnaire highlighted the need to notify a provider, increase bedside monitoring, and recommend and initiate additional medical therapies as priority nursing interventions.

Case Study 4

Case Study 4 discussed the current clinical presentation of a young, school-aged child recovering from an asthma exacerbation being treated on a medical-surgical unit. Eighty-eight percent of nurses stated that they were not concerned by this child's current status. Most responses indicated that nurses agreed that continuing the current treatment regimen, administering PRN medications (i.e. albuterol), coordinating care with a respiratory therapy, and addressing the family's educational deficits were of highest priority.

Case Study 5

This case study tasked nurses to examine the clinical presentation of a 6-month-old male with a complex cardiac history being admitted for pre-hydration prior to a corrective surgery the following day. All nurse participants agree that this child exhibited non-concerning clinical findings consistent with the child's baseline. As such, most nurses recommended continuing the current treatment regimen without need for any modifications at that time.

Discussion

This quality improvement project was designed to modify a Midwestern children's hospital existing pediatric EWS tool utilizing the literature and an interdisciplinary healthcare team's expertise to test the inter-rater reliability of the newly modified tool and evaluate nurses' clinical thinking abilities. Twenty-five nurses employed across three medical-surgical units were recruited and completed scoring of five fictionalized patients within case studies illustrating varying degrees of clinical stability and decompensation. The statistical analysis indicated that the tool had moderate inter-rater reliability among nursing staff. Interestingly, inter-rater reliability was higher in Case Study 3 that exhibited a patient who was clearly clinically decompensating as opposed to a chronically ill patient that may be successfully managed on a medical-surgical unit (Case Studies 1 and 2). Inter-rater reliability was the lowest in Case Study 5, which depicted a clinically stable, chronically ill patient that

Table 4
Questionnaire response themes.

Case	Question	Response Themes (Frequency)
1	Nurse Concern	Potential for decompensation (29)
		Stable clinical status (4)
		Provider has evaluated patient (2)
		Acceptable plan of care in place (2)
	Interventions & Actions	Increase monitoring (28)
		Administer medications (17)
		Recommend further interventions (20)
		Notify provider (21)
		Provide support to patient/family (1)
	Rationale for Interventions	Patient status (7)
		To promote/improve clinical status (12)
		Provider presence needed (1)
		Nurse's concern (1)
		Update provider (2)
	Expected Results	Clinical improvement (12)
		Additional interventions prescribed/initiated (8)
		Provider presence at bedside (3)
		Transfer to a higher level of care (1)
2	Nurse Concern	Current clinical status/Potential for decompensation (29)
	Interventions & Actions	Recommend further intervention (39)
		Notify provider (26)
		Notify RT (13)
		Increase monitoring (13)
		Transfer to higher level of care (5)
		Administer medications (3)
		Notify charge nurse (1)
	Rationale for Interventions	Patient status (11)
		To promote/improve clinical status (8)
		Provider presence needed (3)
	Expected Results	Clinical improvement (9)
		Clinical decompensation (2)
		Additional interventions prescribed/initiated (5)
		Provider presence at bedside (4)
		RT presence at bedside (2)
		Transfer to a higher level of care (8)
3	Nurse Concern	Current clinical status/Potential for decompensation (35)
	Interventions & Actions	Recommend further intervention (40)
		Notify provider (23)
		Notify charge nurse (1)
		Increase monitoring (19)
		Transfer to higher level of care (5)
	Rationale for Interventions	Patient status (16)
		To promote/improve clinical status (7)
	Expected Results	Clinical improvement (7)
		Clinical decompensation (4)
		Additional interventions prescribed/initiated (4)
		Provider presence at bedside (2)
		Transfer to a higher level of care (7)
4	Nurse Concern	Current clinical status/Potential for decompensation (3)
		Stable clinical status (25)
	Interventions & Actions	Continue with current management plan (15)
		No additional interventions required (1)
		Notify provider (1)
		Notify RT (7)
		Educate patient/family (8)
		Administer medications (4)
	Rationale for Interventions	Patient status (6)
		To promote/improve clinical status (2)
		Identified educational needs (3)
	Expected Results	Clinical improvement (8)
		Family's concern addressed (4)
5	Nurse Concern	Stable clinical status (25)
	Interventions & Actions	Continue with current management plan (15)
		No additional interventions required (10)
		Review current management plan (2)
	Rationale for Interventions	Patient status (13)
	Expected Results	No clinical change (2)

exhibited findings that would be concerning in an otherwise healthy patient. Although most nurses agreed that the patient was clinically stable and additional nursing interventions were not required at that time, it appeared that many participants struggled to appropriately score a patient's baseline status using this tool. Further, inconsistency in scoring between nurses was greatest in the behavioral/neurological, cardiovascular, and respiratory sections, with respiratory being the greatest source of variability. This finding is inconsistent with what has been found in previous literature examining the inter-rater reliability of the CHEWS tool, which showed a 100% inter-rater reliability in pediatric patients whose total score was greater than or equal to 3 (McLellan et al., 2014). Possible explanations for this discrepancy include lack of understanding of the terminology utilized within the tool and the appropriate assignment of scores within allotted sections. For example, terms like "irritable" and "drowsy," which are utilized within the behavioral/neurologic section, are subjective in nature and may be interpreted differently among nursing staff. Further, lack of understanding of when to assign a score for a family's concern was evident. Additionally, lack of familiarity with the tool and time constraints may have resulted in skewed scoring.

Although a statistical analysis indicated moderate inter-rater reliability, an examination of the qualitative data indicated a greater consensus among nurses regarding the patients' clinical status and their degree of concern even among cases with low scoring consistency. Most nurses agreed on which patients were clinically concerning and were able to identify appropriate priority nursing interventions for each case. For example, 28% and 44% of nurses correctly identified Case Study 1 and 2's patients' total scores, respectively. In contrast, 84% and 100% of nurses in Case Study 1 and 2, respectively, indicated that they were concerned about these patients' clinical status. This may indicate that nurses may have valid concerns utilizing an objective tool to accurately describe a subjective assessment as discussed by Cassidy et al. (2019). Although the inconsistency between objective scoring and a subjective assessment is a well appreciated weakness of EWS tools, there is little literature detailing its causes or possible solutions (Cassidy et al., 2019; Jensen et al., 2018). As such, further exploration is needed to identify methods (i.e. education, clarification of terminology, etc.) to better synchronize EWS tools' numerical scores with nurses' subjective assessments.

Interestingly, nurses disagreed with the interdisciplinary panel regarding the concerning nature of the patient in Case Study 1. The interdisciplinary panel determined that the patient in Case Study 1 did not warrant a score in the nurse concern category. Rather, the interdisciplinary team concluded that appropriate nursing interventions, such as administering acetaminophen, may address the patient's presenting symptoms (i.e. fever, tachycardia, etc.). However, many nurses scored this patient as clinically concerning and indicated this in the questionnaire. Yet, despite this disagreement, many nurses recommended performing the same interventions as the interdisciplinary team.

Likewise, nurses identified the same interventions as, if not more than, the interdisciplinary team in case studies 2, 3, 4, and 5. This is surprising considering the considerable discrepancies in scoring in many of the categories as well as the total score in many of these cases. This further bolsters the concern that an objective score may not adequately represent the extent of a nurse's concern about a patient and the subsequent interventions needed.

Study limitations

Due to this study's nature, it is susceptible to notable limitations. A primary limitation within this study was the relatively small sample size ($n = 25$) utilized to examine the inter-rater reliability. In ideal circumstances, a larger sample size would have been recruited for more reliable results. However, recruiting participants was impacted by the COVID-19 pandemic and its subsequent restrictions on direct access to nursing staff. Additionally, the COVID-19 pandemic altered the original plans to educate the staff about the new tool, in person. Instead, this researcher provided written instructions as opposed to the preferred, in-depth educational sessions originally intended.

Further, the length of and time required to complete all five case studies may have dissuaded nurses from completing the case studies all-together or impacted their ability to devote adequate attention to appropriately score each fictionalized patient, especially as this was designed to be completed throughout the course of a nurse's shift. Finally, results may be skewed as a majority of the participants were employed on one of the medical-surgical units. As each unit has different specializations (i.e. non-invasive mechanical ventilation trained staff, patient diagnoses, etc.), scores could have been influenced by nurses' unfamiliarity with certain conditions and treatment regimens.

Future work

The results of this study are promising and indicate a potential benefit to utilization of this pediatric EWS tool on medical-surgical units. However, a more extensive evaluation of its effectiveness is warranted. Future steps to improve inter-rater reliability may include interventions such as clarification of the tool's terminology, staff education, and a robust explanation of how to score patients may be beneficial. Practicing this new skill with high-fidelity simulation may also improve acceptance and better utilization of this tool. Once a high level of inter-rater reliability is achieved, testing on admitted pediatric patients treated on medical-surgical units to ensure the tool's accuracy in identifying patients who are clinically decompensating and preventing unplanned transfers to the PICU and cardiac and respiratory arrests outside of the ICU should commence.

Conclusion

Pediatric patients are often treated outside of the PICU. However, their initial admission to a medical-surgical unit does not rule out the possibility of clinical decompensation, an unplanned transfer to a higher level of care, or a cardiac or respiratory arrest. As such, pediatric EWS have been implemented across pediatric healthcare facilities in order to prevent these unintended outcomes. The results of this study, in combination with current literature, are promising, indicating that this tool may serve to better identify these patients.

Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Declaration of interest

None.

Acknowledgments

Alexander Hall, Statistician Interprofessional Team at Creighton University in Omaha, NE.

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