Utility of Pediatric Early Warning Scoring System in Predicting Clinical Deterioration in Children: A Review

Rasikapriya Duraisamy¹, Banupriya Balasubramanian², Soundararajan Palanisamy³

ABSTRACT

Objective: To review the available evidence on effectiveness of the pediatric early warning score (PEWS) in predicting clinical deterioration in children in healthcare settings.

Materials and methods: The electronic databases like PubMed, Google Scholar, etc., were searched up to December 2018, systemically using keywords including early warning scoring system, rapid response, pediatric, and severity of illness. Studies included should have used PEWS for assessing the severity in children in bedside, emergency, and oncology settings. The outcome had to identify the clinical deterioration in children and shifting to PICU/activation of the rapid response team. Results were normatively synthesized.

Results: On total screening of 1,254 papers, 52 papers met the criteria and 10 papers were included to write the review article as it met the inclusion criteria. It revealed that PEWS is used extensively in varied settings. But still PEWS had limited use because of variation of scores according to settings. Positive outcomes were identification of sick children and intervention with multidisciplinary team work and effective communication and confidence in treating children.

Conclusion: Despite many studies reporting the usefulness of PEWS, no evidence was available for which PEWS to be used. Further research on PEWS is needed for assessing the impact of PEWS implementation and outcome in resource-limited settings.

Keywords: Early warning scoring system, Pediatric, Rapid response, Severity of illness.

SBV Journal of Basic, Clinical and Applied Health Science (2019): 10.5005/jp-journals-10082-02221

INTRODUCTION

Children with varying severity of illness seek medical care. To categorize the children into well and unwell, triaging them is important. Identifying a sick child on time provides a good outcome with less morbidity and mortality. To provide an integral and holistic care, a proper scoring system is required. Hospitalized mortality was mainly attributed to failure in picking up the deteriorating clinical signs in children and intervenes immediately. Early warning scores are initially used in adult patients to identify clinical deterioration earlier to provide effective intervention and better outcome. It was combined with an emergency medical response team for an effective outcome and to provide proper communication between the emergency department and ward/ICU.

The concept can be applied to children for a good integral health care system, starting from the emergency department where nurses and residents can be trained in identifying early deterioration with simple clinical parameters. Golden hour in children is very important as they can succumb fast compared to adults who can withstand stress. Managing a child in the emergency requires skill and knowledge about vital parameters, where a scoring can help health personnel to identify a critically ill child.

Similar to adults, multiple scoring systems were applied in children in the ward, PICU, and the emergency department to provide quality care and better outcome.¹⁻⁸ It was found that children who had sudden cardiopulmonary arrest showed clinical parameters deteriorating 24 hours prior to the event.

The inpatient hospital cardiac arrests lack the data collection and analysis. Cardiac arrest in the children can be due to three complications such as respiratory arrest, severe bradycardia, and pulseless cardiac arrest.⁹ These conditions are recorded with varied interchangeability. In the early 1990s, international experts developed the set of guidelines for data reporting of cardiac arrests and resuscitation.¹⁰ The American Heart Association started a National Registry of Cardiopulmonary Resuscitation to collect a large database of hospital cardiac arrests and resuscitation with Utstein-style definitions. The outcome measures are all recorded to determine an intervention that could have been done for averting a death.

Advances in resuscitation care like basic life-support courses in the decade have resulted in increasing rates of survival for patients with out-of-hospital cardiac arrest.¹¹ In the in-hospital setting, efforts to improve quality include the use of routine mock codes, post-resuscitation debriefing, and defibrillation machine brought by the specialized code personnel. Code teams respond to sudden arrests that occur in the hospital and resuscitate within the window period of 3–5 minutes for a return of spontaneous circulation. In a study done by Nadkarni et al., it was found that 0.7–3% patients sustained cardiac arrest during the hospital stay in the ward/ICU/ emergency room.¹² Hence, a proper scoring system that can be...
easily done by nurses and residents is required. Identification of early clinical deterioration is crucial in resource-limited settings, as it will facilitate timely clinical decisions and referral. The purpose of this review is to evaluate the utility of PEWS in predicting clinical deterioration in children.

**Materials and Methods**

Articles for review were obtained by searching Web of Science, PubMed, and Google Scholar for all entries from database inception to December 2018. The databases were searched using key words including early warning scoring system, rapid response, pediatric, and severity of illness.

This search identified 1,254 articles, from which 52 were found to be potentially relevant to this study. The review of the abstracts identified 10 articles meeting the inclusion criteria for this review. The reference lists of included articles did not identify any further articles meeting the inclusion criteria.

Information was obtained from the included studies regarding the setting, study population, study design, objectives, PEWS version used, and outcome measured.

**Results**

**Study Characteristics**

The literature search identified 10 publications satisfying the inclusion criteria. The characteristics of these studies can be found in Tables 1 and 2. The studies took place in Canada, Guatemala, Brighton, London, United states, Toronto, Ireland, Los Angeles, and Boston. One study was multicentric study and data were collected from seven countries. All the studies were done in large referral hospitals, including one in a pediatric oncology hospital. Outcomes measured in these studies were activation of a rapid response team and/or transfer to PICU.

Studies included in this review have been listed in Table 1 and specificity, sensitivity, positive predictive value (PPV), and negative predictive value (NPV) of PEWS in these studies have been listed in Table 2.

**Discussion**

The PEWS comprises of early detection, implementation of score, and response to score by a medical team. The PEWS is being used with different components in different settings. Superiority of one PEWS over the other has not been shown in multicentric studies.

Most of studies were conducted in higher centers where equipment are available for scoring. Settings included were bedside, ward, oncology department, and emergency departments. This evidence suggests the need for further direction of studies in one PEWS with effective components, implementation in low-income to middle-income countries, and varied outcomes measures.

The review revealed positive outcomes in reduction of death due to the cardiopulmonary cause by early detection and intervention with enhanced multidisciplinary team work and communication in shifting the patients to PICU.

The review stated that multiple PEWSs are in use across the world, yet no strong evidence on effective PEWS in settings. These differences might be due to how they developed a detection tool, investigated and modified according to their settings for feasibility and easy use. It was found with many diversity that PEWS had high specificity and sensitivity. Only few used validated PEWS that showed promising performance. Many selected PEWSs, which were simple and easy to apply without high equipment. The variety in use of PEW parameters reflected the desire of having locally derived systems. A proper standardized common scoring system among healthcare professionals for identification and intervention to sick children is necessary. Only one multicentric study done across seven countries by using validated PEWS showed promising results, which implies a proper validated score can be used across countries.

The review found that the main response was to active the rapid response team and shift the children to PICU. There were no uniformity on activation of the rapid response team (two studies used score 6 to active team where one study used score 4 to active the team) and uncertainty on timely intervention in clinical deteriorating children. Further direction on family-activated response is needed for demonstration of a better outcome. The review identified that multifaceted nature of PEWS (communication, parent involvement, and team work) to be implemented for a better outcome in children. Further directions include proactive assessment of at-risk children for clinical deterioration as a reactive response.

**Strengths and Limitations**

The review article collected the evidence on PEWS with varied components and outcomes. There is risk of publication bias. There is potentially other literature likely to be of relevance to informing the effectiveness of PEWS — most specifically to examine sociocontextual factors (e.g., situation awareness and human factor) that may, or may not, influence the implementation of PEWS.
Utility of Pediatric Early Warning Scoring System in Predicting Clinical Deterioration in Children

**Table 2: Performance of different pediatric early warning scores**

| Citation          | Markers of clinical deterioration/end point | Threshold score cut-point | Sensitivity (%) | Specificity (%) | Positive predictive value (%) | Negative predictive value (%) |
|-------------------|---------------------------------------------|---------------------------|-----------------|-----------------|------------------------------|-------------------------------|
| Akre et al.        | RRT call, code blue call                    | ≥4                        | 78              | 95              | 91.7                         | 99.8                          |
| Duncan et al.      | Code blue call                              | ≥2                        | 90              | 95              | 72.9                         | 72.9                          |
| Parshuram et al.   | Respiratory or cardiac arrest, HDU/PICU     | ≥2                        | 70              | 86              | 99                           | 99.7                          |
| Egdell et al.      | Medical interventions                       | ≥8                        | 88              | 99              | 72.9                         | 72.9                          |
| Haines et al.      | Unplanned ICU admission                     | ≥8                        | 66              | 99              | 72.9                         | 72.9                          |
| Middaugh et al.    | Unplanned ICU admission without code blue   | ≥7                        | 93              | 85              | 89                           | 89                            |
| Parshuram et al.   | Unplanned ICU admission without actual      | ≥5                        | 84              | 62              | 89                           | 89                            |
| Parshuram et al.   | Patients transferred to PICU after a physician’s request | ≥3 | 81 | 89 | 74.4 | 74.4 |

**Conclusion**

This review identified that PEWS are widely used internationally. The evidence revealed a lack of consensus on which PEWS is most effective or useful and positive outcomes on improving patient care. Lack of multicentric trials and no proper national guidelines question the consistency of application of PEWS. Further research on PEWS is needed for assessing the impact of PEWS implementation and outcome in resource-limited settings.

**Author Contribution**

All the authors were involved in the management of the patients.

**References**

1. Chaiyakulsil C, Pandee U. Validation of pediatric early warning score in pediatric emergency department. Pediatr Int 2015;57(4):694–698. DOI: 10.1111/pedi.12595.
2. Parshuram CS, Hutchison J, Middaugh K. Development and initial validation of the bedside paediatric early warning system score. Crit Care 2009;13(4):R135. DOI: 10.1186/cc7998.
3. Breslin K, Marx J, Hoffman H, McBeth R, Pavuluri P. Pediatric early warning score at time of emergency department disposition is associated with level of care. Pediatr Emerg Care 2014;30(2):97–103. DOI: 10.1097/PEC.000000000000066.
4. Panesar R, Polkoff LA, Harris D, Mills B, Messina C, Parker MM. Characteristics and outcomes of pediatric rapid response teams before and after mandatory triggering by an elevated pediatric early warning system (PEWS) score. Hosp Pediatr 2014;4(3):135–140. DOI: 10.1542/hped.2013-0062.
5. Gold DL, Mihalov LK, Cohen DM. Evaluating the pediatric early warning score (PEWS) system for admitted patients in the pediatric emergency department. Acad Emerg Med 2014;21(11):1249–1256. DOI: 10.1111/acem.12514.
6. Parshuram CS, Bayliss A, Reimer J, Middaugh K, Blanchard N. Implementing the bedside paediatric early warning system in a community hospital: a prospective observational study. Paediatr Child Health 2011;16(3):e18–e22. DOI: 10.1093/pch/16.3.e18.
7. Egdeff P, Finlay L, Pedley DK. The PAWS score: validation of an early warning scoring system for the initial assessment of children in the emergency department. Emerg Med J 2008;25(11):745–749. DOI: 10.1136/emj.2007.054965.
8. Duncan H, Hutchison J, Parshuram CS. The pediatric early warning system score: a severity of illness score to predict urgent medical need in hospitalized children. J Crit Care 2006;21(3):271–278. DOI: 10.1016/j.jcrc.2006.06.007.
9. Nadkarni VM, Larkin GL, Peberdy MA, Carey SM, Kaye W, Mancini ME, et al. First documented rhythm and clinical outcome from in-hospital cardiac arrest among children and adults. JAMA 2006;295(1):50–57. DOI: 10.1001/jama.295.1.50.
10. Zanitsky A, Nadkarni V, Hazinski MF, Foltin G, Quan L, Wright J, et al. Recommended guidelines for uniform reporting of pediatric advanced life support: the pediatric Utstein style. A statement for healthcare professionals from a task force of the American Academy of Pediatrics, the American Heart Association, and the European Resuscitation Council. Resuscitation 1995;30(2):95–115. DOI: 10.1016/0300-9572(95)00884-v.
11. Hinchey PR, Myers JB, Lewis R, De Maio VJ, Reyer E, Licatese D, et al. Improved out-of-hospital cardiac arrest survival after the sequential implementation of 2005 AHA guidelines for compressions, ventilations, and induced hypothermia: the wake county experience. Ann Emerg Med 2010;56(4):348–357. DOI: 10.1016/j.annemergmed.2010.01.036.
Utility of Pediatric Early Warning Scoring System in Predicting Clinical Deterioration in Children

12. Monaghan A. Detecting and managing deterioration in children. Paediatr Nurs 2005;17(1):32–35. DOI: 10.7748/paed2005.02.17.1.32.c964.

13. Tucker KM, Brewer TL, Baker RB, Demeritt B, Vossmeyster MT. Prospective evaluation of a pediatric inpatient early warning scoring system. J Spec Pediatr Nurs 2009;14(2):79–85. DOI: 10.1111/j.1744-6155.2008.00178.x.

14. Parshuram CS, Duncan HP, Joffe AR, Farrell CA, Lacroix JR, Middaugh KL, et al. Multicentre validation of the bedside paediatric early warning system score: a severity of illness score to detect evolving critical illness in hospitalised children. Crit Care 2011;15(4):R184. DOI: 10.1186/cc10337.

15. Ennis L. Paediatric early warning scores on a children’s ward: a quality improvement initiative. Nurs Child Young People 2014;26(7):25–31. DOI: 10.7748/ncyp.26.7.25.e478.

16. Mandell IM, Bynum F, Marshall L, Bart R, Gold JI, Rubin S. Pediatric early warning score and unplanned readmission to the pediatric intensive care unit. J Crit Care 2015;30(5):1090–1095. DOI: 10.1016/j.jcrc.2015.06.019.

17. Agulnik A, Méndez Aceituno A, Mora Robles LN, Forbes PW, Soberanis Vásquez DJ, Mack R, et al. Validation of a pediatric early warning system for hospitalized pediatric oncology patients in a resource-limited setting. Cancer 2017;123(24):4903–4913. DOI: 10.1002/cncr.30951.

18. Parshuram CS, Dryden-Palmer K, Farrell C, Gottesman R, Gray M, Hutchison JS, et al. Effect of a pediatric early warning system on all-cause mortality in hospitalized pediatric patients: the EPOCH randomized clinical trial. JAMA 2018;320(10):1002–1012. DOI: 10.1001/jama.2018.0948.

19. Akre M, Finkelstein M, Erickson M, Liu M, Vanderbilt L, Billman G. Sensitivity of the pediatric early warning score to identify patient deterioration. Pediatrics 2010;125(4):e763–e769. DOI: 10.1542/peds.2009-0338.

20. Edwards ED, Powell CVE, Mason BW, Oliver A. Prospective cohort study to test the predictability of the Cardiff and Vale paediatric early warning system. Arch Dis Child 2009;94(8):602–606. DOI: 10.1136/adc.2008.142026.

21. Fuijkschot J, Vemhout B, Lemson J, Draisma JMT, Loeffen JLCM. Validation of a paediatric early warning score: first results and implications of usage. Eur J Pediatr 2015;174(1):15–21. DOI: 10.1007/s00431-014-2357-8.

22. Haines C, Perrott M, Weir P. Promoting care for acutely ill children: development and evaluation of a paediatric early warning tool. Intensive Crit Care Nurs 2006;22(2):73–81. DOI: 10.1016/j.iccn.2005.09.003.

23. McLellan MC, Gauvreau K, Connor JA. Validation of the cardiac children’s hospital early warning score: an early warning scoring tool to prevent cardiopulmonary arrests in children with heart disease. Congenit Heart Dis 2014;9(3):194–202. DOI: 10.1111/chd.12132.

24. Robson M-AJ, Cooper CL, Medicus LA, Quintero MJ, Zuniga SA. Comparison of three acute care pediatric early warning scoring tools. J Pediatr Nurs 2013;28(6):e33–e41. DOI: 10.1016/j.pedn.2012.12.002.

25. Skaletzky SM, Rasznyski A, Totapally BR. Validation of a modified pediatric early warning system score: a retrospective case-control study. Clin Pediatr (Phila) 2012;51(5):431–435. DOI: 10.1177/0009922811430342.

26. Seiger N, Maconochie I, Oostenbrink R, Moll HA. Validity of different pediatric early warning scores in the emergency department. Pediatrics 2013;132(4):e841–e850. DOI: 10.1542/peds.2012-3594.

27. Bradman K, Maconochie I. Can paediatric early warning score be used as a triage tool in paediatric accident and emergency? Eur J Emerg Med 2008;15(6):359–360. DOI: 10.1097/MEJ.0b013e3283026208.

28. Thokchom M, Pande V, Jacob E. Abstract P-037: Prospective observational study to develop paediatric acute care score (PACS) for early prediction of clinical deterioration in children admitted to paediatric wards through emergency services. Pediatric Critical Care Medicine 2018;19(65):60. DOI: 10.1097/01.pcc.0000537494.87680.57.