

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

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## 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.

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## 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.<sup>1-8</sup> 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.<sup>9</sup> These conditions are recorded with varied interchangeability. In the early 1990s, international experts

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developed the set of guidelines for data reporting of cardiac arrests and resuscitation.<sup>10</sup> 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.<sup>11</sup> 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.<sup>9</sup> 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.<sup>18</sup>

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

**Table 1:** PEWS in different settings

Author	Year	Place	Sample size	Method (study)	Settings	PEWS tool
Monaghan <sup>12</sup>	2005	Brighton	60	Prospective cohort	Bedside to PICU	Brighton PEWS
Duncan et al. <sup>8</sup>	2006	London	87 cases 128 controls	Case-control	Bedside to ICU	Modified PEWS
Tucker et al. <sup>13</sup>	2009	United States	2,979	Prospective, descriptive	Ward	PEWS
Parshuram et al. <sup>2</sup>	2009	Canada	60 cases 120 controls	Case-control	Bedside to ICU	Bedside PEWS
Parshuram et al. <sup>14</sup>	2011	Canada	2,074	Case-control	Bedside	Bedside PEWS
Parshuram et al. <sup>6</sup>	2011	Toronto	842 before, 2,350 after	Prospective, observational	Ward	Bedside PEWS
Ennis <sup>15</sup>	2014	Ireland	1,618	Prospective	Ward	PEWS
Mandell et al. <sup>16</sup>	2015	Los Angeles	189	Case-control	PICU to ward	Children's Hospital LA. PEWS
Agulnik et al. <sup>17</sup>	2016	Boston	2,000	Prospective	Oncology ward	Modified PEWS
Parshuram et al. <sup>18</sup>	2018	7 countries	144,539	Multicenter cluster randomized trial	Ward	Bedside PEWS

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

Citation	PEWS	Marker of clinical deterioration/end point	Threshold/ score cut-point	AUC/ROC (%)	Sensitivity (%)	Specificity (%)	Positive pre- dictive value (%)	Negative predictive value (%)
Akre et al. <sup>19</sup>	Modified Brighton PEWS	RRT call, code blue call	≥ 4	-	78	95	-	-
Duncan et al. <sup>8</sup>	PEW system score (Birmingham/Toronto)	Code blue call	5	90	78	95	4.2	-
Edwards et al. <sup>20</sup>	Cardiff and Vale PEWS	Respiratory or cardiac arrest, HDU/PICU admission, death	≥ 2	86	70	90	5.9	99.7
Fuijkschot et al. <sup>21</sup>	Modified Bedside PEWS	Unplanned ICU admission, need for emergency medical interventions	≥ 8	-	67	88	-	-
Haines et al. <sup>22</sup>	Bristol PEWS	Escalation to a higher level of care	≥ 1	-	99	66	-	-
McLellan et al. <sup>23</sup>	C-CHEWS	Unplanned ICU transfer	≥ 5	92	67.2	93.6	72.9	91.7
Parshuram et al. <sup>2</sup>	Bedside PEWS	Urgent ICU admission without a code blue call	≥ 8	91	82	93	-	-
Parshuram et al. <sup>6</sup>	Bedside PEWS	Urgent ICU admission without code blue	≥ 7	87	64	91	-	-
Robson et al. <sup>24</sup>	PEW system score (by Duncan)	RRT call for impending or actual cardiopulmonary arrest	5	85	86.6	72.2	-	-
Skaletzky et al. <sup>25</sup>	Modified Brighton PEWS	Patients transferred to PICU after a physician's request, rapid response team evaluation	2.5	81	62	89	-	-
Tucker et al. <sup>13</sup>	Modified Brighton PEWS	Unplanned transfer to PICU	≥ 3	89	90.2	74.4	7.2	99.8

not, work as active ingredients in the successful implementation of PEWS. There is some work emerging in this area.<sup>26-28</sup>

**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.

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