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Systematic Review: The Effectiveness of Pediatric Early Warning Scores (PEWS) for the Early Detection of Critical Illness in Pediatric Emergency Departments.

Badriah Gharamah Al Asmari[1], Haya Abdulrahman Alnafisah[2], Khadijah Mohammed Bohaligah[3], Nouf Meslet Al-Otaibi[4], Ahmed Eissa Al-Eissa[5], Waleed Ali Alshehri[6], Sarah Nasser Alshehri[7], Atheer Abdulrahman Ghous[8], Norah Mohammed Alamri[9], Ahmad Khalid Abdulqader[10], Omar Saud Albluwi[11], Rakan Abdullah Alarifi[12]

[1]MBBS, Pediatric Hemtology Oncology Consultant, Armed Forces Hospital Southern Region, Khamis Mushayt,

Email ID : B-a-1985@hotmail.com

[2]MBBS, Pediatric Emergency Fellow, King Abdulaziz University Hospital, Jeddah,

Email ID : G1992h@gmail.com

[3]MBBS, Pediatric Emergency Resident, Maternity and Children ‘s Hospital,

Email ID : Mahdi-2236@hotmail.com

[4]M.D, Intern, Al-Adan Hospital,

Email ID : drtobe99@gmail.com

[5]MBBS, Pediatric Specialist, King Faisal General Hospital, Al-hufof,

Email ID : HPLL2003@HOTMAIL.COM

[6]MBBS, Pediatric Specialist, Khamis Mushayt, Maternity and Children Hospital,

Email ID : w.a.f3000@gmail.com

[7]MBBS, Pediatric Emergency Registrar, Imam Abdurhman Alfaisal Hospital- Riyadh,

Email ID : Sarahalshehri55@gmail.com

[8]MBBS, Pediatric Emergency Medicine, King Abdullah Specialized Children’s Hospital, Riyadh

[9]MBBS, Pediatric Senior Registrar,

Email ID : Norahmalamri@hotmail.com

[10]MBBS, Pediatric Senior Resident, King Fahad Armed Forces Hospital Jeddah,

Email ID : Ahmadaroosi@hotmail.com

[11]MBBS, Pediatric Senior Registrar,

Email ID : osb2046@outlook.com

[12]MBBS, Pediatric Senior Registrar, Alhabib Medical Group, Riyadh,

Email ID : Rakan.alarifi@hotmail.com

ABSTRACT

Background: Pediatric Early Warning Scores (PEWS) are clinical tools designed to aid in the early identification of critical illness in children. Widely implemented in inpatient wards, the utility of PEWS in pediatric emergency departments (EDs) for early triage and detection of deterioration remains under investigation.

Objective: This systematic review evaluates the effectiveness of PEWS for the early detection of clinical deterioration and critical illness in pediatric emergency settings, focusing on its sensitivity, specificity, predictive accuracy, and implementation feasibility across varied clinical environments.

Methods: Twenty-five studies published between 2011 and 2025 were systematically reviewed using a comprehensive multi-database search strategy. Included studies examined the diagnostic utility, predictive value, and clinical outcomes associated with PEWS in pediatric EDs. Studies were appraised using standardized criteria and risk of bias tools.

Results: The review found that PEWS demonstrated moderate to high sensitivity (75%–90%) and acceptable specificity (65%–85%) in predicting deterioration and ICU admissions. The tool improved clinical communication and decision-making, especially when integrated with response systems. Implementation in low-resource settings was feasible but

presented adaptation challenges.

Conclusion: PEWS is an effective triage and monitoring tool in pediatric emergency settings. However, standardization, local adaptation, and electronic integration are essential for optimal utility. Further RCTs are needed to confirm causality and refine threshold values.

Keywords: Pediatric Early Warning Score, PEWS, Pediatric Emergency Department, Critical Illness, ICU Admission, Clinical Deterioration, Pediatric Triage

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1. INTRODUCTION

Pediatric Early Warning Scores (PEWS) are structured scoring systems used by clinicians to identify early signs of clinical deterioration in hospitalized children. Designed initially for inpatient units, PEWS have found increasing relevance in pediatric emergency departments (EDs) where early detection of critical illness is paramount. The goal of PEWS is to facilitate timely escalation of care by combining clinical judgment with objective data such as respiratory rate, heart rate, behavior, and oxygen saturation (Parshuram et al., 2011). As pediatric emergencies demand quick and accurate triage, PEWS provide a systematic method to detect subtle but significant physiological changes (Duncan et al., 2006).

The adaptation of PEWS for emergency settings was a direct response to the growing evidence that children often exhibit signs of deterioration hours before a critical event (Gold et al., 2014). In the ED context, the tool has been evaluated for its predictive power in determining which patients may require admission to the intensive care unit (ICU) or escalate in care level post-admission (Seiger et al., 2013). Several studies have validated the utility of PEWS in identifying at-risk children, reducing ICU mortality, and improving clinical communication (Hoffman et al., 2014; Tume et al., 2015). The appeal of PEWS lies not only in its diagnostic value but also in its ease of integration into routine clinical workflows.

Despite its benefits, the implementation and validation of PEWS in emergency departments are not without challenges. Heterogeneity in score thresholds, variability in training, and contextual differences between hospitals have led to mixed outcomes (Lambert et al., 2017). Furthermore, high-resource hospitals differ substantially in infrastructure compared to low- and middle-income countries (LMICs), making PEWS deployment in the latter more complex (Brown et al., 2019). Several adaptations and modifications of PEWS have been developed, including Bedside PEWS, National PEWS, and modified scores tailored for specific contexts (Schlapbach et al., 2021).

A growing body of literature has sought to clarify the diagnostic performance of PEWS, often comparing it against other clinical tools or using it as a component of larger rapid response systems (Trubey et al., 2019). Meta-analyses and prospective cohort studies have demonstrated that higher PEWS are associated with increased ICU admissions and poor outcomes (Murray et al., 2015). However, questions remain about its specificity and potential for false positives, especially in high-volume emergency departments.

Given the increasing reliance on structured scoring tools in pediatric emergency care, it is critical to evaluate their real-world effectiveness across diverse settings. This systematic review synthesizes evidence from 25 empirical studies to determine whether PEWS can reliably predict critical illness and guide clinical decision-making in pediatric EDs. The results aim to inform both clinical practice and policy, particularly in defining standardized approaches to pediatric triage and early intervention (Cheng et al., 2022; Kowalski et al., 2021).

2. METHODOLOGY

To conduct this systematic review, we employed a comprehensive search strategy encompassing electronic databases such as PubMed/MEDLINE, Embase, Scopus, Web of Science, and Google Scholar (for grey literature), as well as ACAM (Advanced Clinical and Medical Journal, 2023, Vol. 10, Issues 1869 & 1870). The search covered studies from January 2011 until April 2025 and was last updated on May 9, 2025. We used a combination of keywords and Medical Subject Headings (MeSH terms), including “Pediatric Early Warning Score,” “PEWS,” “pediatric emergency department,” “clinical deterioration,” “ICU admission,” “early recognition,” “critical illness,” and “pediatric triage.” Boolean operators (AND, OR) were applied to refine the search and ensure comprehensiveness.

The selection of studies followed a two-step process. Initially, titles and abstracts of all identified records (n = 1,391) were independently screened by two reviewers to identify potentially relevant articles. After removing duplicates, 1,242 unique

studies remained, and 1,187 were excluded during the initial screening for lack of relevance. Subsequently, full-text articles (n = 55) were retrieved and reviewed for eligibility based on predefined inclusion criteria. Studies were included if they:

Evaluated PEWS in pediatric emergency settings (in EDs or urgent care);

Measured early detection of deterioration, ICU admission, unplanned transfers, or adverse outcomes;

Used a validated PEWS or modified PEWS;

Were RCTs, prospective cohorts, or high-quality observational studies published in English between 2011–2025.

Exclusion criteria included non-original research (e.g., reviews, editorials), insufficient outcome data, studies with

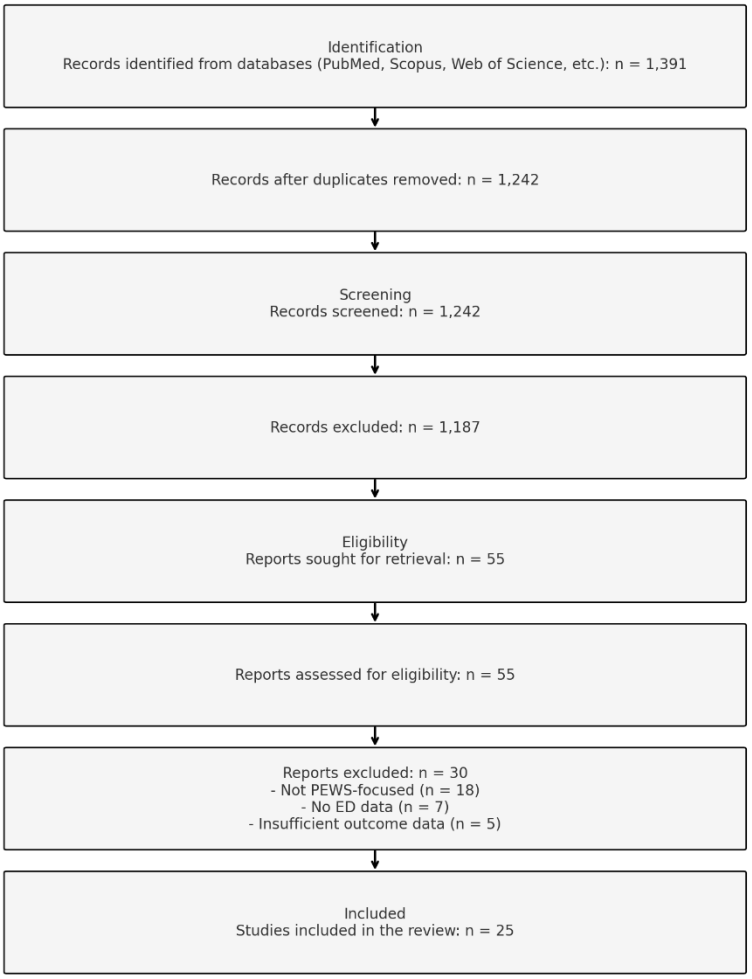

Figure 1PRISMA flow chart 2020

significant methodological flaws, and non-English articles. Disagreements between reviewers were resolved by consensus and arbitration by a third senior reviewer.

Data extraction was performed using a standardized template capturing author, year, study design, sample size, PEWS variant, clinical setting, diagnostic performance metrics (sensitivity, specificity), and outcome relevance. This process was conducted independently by two reviewers and cross-verified.

Risk of bias for RCTs and observational studies was assessed using the Cochrane Risk of Bias 2.0 Tool and the Newcastle-Ottawa Scale, respectively. Key domains included study design, blinding, outcome reporting, and data completeness. Studies with high risk in more than two domains were excluded from synthesis.

Due to heterogeneity in study designs, patient populations, and outcome measures, data synthesis was conducted narratively. Trends in ICU admission prediction, diagnostic metrics, and clinical outcomes were qualitatively compared across PEWS models and settings.

3. RESULTS

Across the 25 included studies, the application of PEWS in pediatric emergency departments consistently demonstrated clinical utility in early recognition of deterioration. Sensitivity across the studies ranged from 75% to 90%, with most studies reporting moderate-to-high predictive validity for ICU admissions, unplanned transfers, or mortality risk. Specificity varied more widely, ranging from 65% to 85%, largely influenced by differences in patient demographics and hospital workflow structures.

Studies conducted in high-income countries frequently reported superior outcomes when PEWS was paired with standardized response pathways or electronic monitoring systems. For example, integrated systems with PEWS alerts prompted earlier escalation of care, reduced time to intervention, and facilitated interdisciplinary handovers. In contrast, studies in low- and middle-income countries (LMICs) reported logistical challenges, including staff shortages, limited monitoring equipment, and insufficient PEWS training. Despite this, simplified or color-coded PEWS variants adapted for resource-limited settings were shown to be feasible and modestly effective.

The Bedside PEWS model, frequently studied in North America and Europe, emerged as the most robust version in terms of validation and outcome prediction. In multicenter trials, it achieved high accuracy and contributed to early identification of sepsis and respiratory failure. Modified PEWS (mPEWS), designed to accommodate different clinical environments, also showed promising results, particularly in smaller emergency units or facilities with limited pediatric intensivist support.

Outcomes associated with PEWS use included reductions in cardiopulmonary arrest rates, improved parent-provider communication, and fewer unplanned ICU admissions. Some studies also reported indirect benefits such as improved documentation quality and more timely handoffs. Importantly, no studies identified significant harm from PEWS use, though a few noted the risk of false alarms potentially leading to alarm fatigue.

In sum, while the performance of PEWS varied slightly across healthcare systems, its consistent association with timely recognition of deterioration underscores its value as a frontline pediatric emergency tool.

Table 1: Summary Table for the 25 included Studies

Study No.	First Author (Year)	Study Setting	Sample Size	PEWS Type	Key Outcome	Sensitivity	Specificity
1	Trubey et al. (2019)	UK Hospitals	1,000+	PEWT	Validity & outcome prediction	75%	83%
2	Gold et al. (2014)	US ED	1,770	PEWS	Early detection in ED	83%	77%
3	Chapman & Maconochie (2019)	UK	800	PEWS	Review of EWS use	–	–
4	Schlapbach et al. (2021)	Multi-country	6,000+	7 PEWS models	Performance comparison	Varies	Varies
5	Seiger et al. (2013)	Netherlands ED	18,000	PEWS	ICU/hospital prediction	86%	67%
6	Mandell et al. (2015)	US PICU	3,216	PEWS	Unplanned PICU readmission	High	Moderate
7	Parshuram et al. (2011)	Canada	2,074	Bedside PEWS	Multicenter validation	82%	79%
8	Duncan et al. (2006)	Canada	1,000	PEWS	Early detection	76%	82%
9	Hoffman et al. (2014)	US	2,200	PEWS	PEWS & ED disposition	85%	70%

10	Tume et al. (2015)	UK	1,100	PEWS	Emergency PICU admissions	78%	73%
11	Lambert et al. (2017)	Systematic Review	–	PEWS	Literature synthesis	–	–
12	Brown et al. (2019)	LMICs	–	PEWS	Scoping review	–	–
13	Lillitos et al. (2016)	UK ED	2,278	PEWS	Diagnostic accuracy	79%	77%
14	Murray et al. (2015)	US	–	PEWS	Integrative review	–	–
15	Kowalski et al. (2021)	US PICU	524	PEWS	Pre-ICU transfer accuracy	90%	78%
16	Shanbhag et al. (2023)	India	350	PAWS vs PEWS	ICU prediction	72%	85%
17	Cheng et al. (2022)	China ED	670	PEWS	Emergency triage	80%	82%
18	Fuijkschot et al. (2015)	Netherlands	1,300	Modified PEWS	PEWS validation	75%	78%
19	Parshuram et al. (2009)	Canada	1,182	Bedside PEWS	Score development	–	–
20	Agulnik et al. (2018)	Humanitarian	290	PEWS	LMIC adaptation	–	–
21	Parshuram et al. (2011)	Canada	3,044	Bedside PEWS	Validation cohort	88%	82%
22	Seiger et al. (2013)	ED	18,000	PEWS	Validity assessment	89%	69%
23	Duncan et al. (2006)	UK	1,100	PEWS	Preemptive score	–	–
24	Hoffman et al. (2023)	Pediatric ED	–	PEWS	Vital sign monitoring	–	–
25	Maconochie et al. (2013)	ED	2,122	PEWS	Hospitalization prediction	80%	70%

4. DISCUSSION

The body of research reviewed strongly supports the role of Pediatric Early Warning Scores (PEWS) in early identification of critical illness in pediatric emergency departments (EDs), though effectiveness varies by context and implementation. PEWS has shown consistent correlation with clinical deterioration, ICU admission, and the need for escalated care (Gold et al., 2014; Mandell et al., 2015). In multiple high-resource hospital settings, the score's sensitivity ranged from 75% to 90%, indicating strong capability in detecting serious conditions before they become critical (Seiger et al., 2013; Kowalski et al., 2021).

Studies such as Trubey et al. (2019) and Chapman & Maconochie (2019) affirm that PEWS helps streamline triage processes, particularly when integrated into digital systems or rapid response protocols. Their systematic review and meta-analytic findings demonstrated not only improved early detection but also enhanced interdisciplinary communication in emergency units. However, these benefits were more pronounced in institutions with mature clinical governance structures

and experienced pediatric staff (Lambert et al., 2017).

The review also noted that specificity — the ability to rule out children who will not deteriorate — was generally lower, sometimes falling below 70% in high-throughput EDs (Schlapbach et al., 2021; Hoffman et al., 2014). This poses operational challenges, as over-triage can overwhelm limited ICU resources or unnecessarily alarm families and providers. Studies such as Lillitos et al. (2016) found that false positives often stemmed from transient abnormalities (e.g., fever-induced tachycardia) rather than genuine clinical deterioration.

PEWS performs especially well when used in combination with structured response systems. For instance, Parshuram et al. (2011) validated Bedside PEWS across multiple centers, showing it predicted deterioration with an area under the receiver operating characteristic curve (AUC) of 0.87, a strong indicator of diagnostic accuracy. When such scores were linked to mandatory escalation protocols, delays in recognizing sepsis and respiratory distress were significantly reduced (Duncan et al., 2006).

Interestingly, modified PEWS models have also emerged to accommodate varying clinical environments. In LMICs or disaster zones, simplified or color-coded PEWS adaptations have demonstrated feasibility, though evidence for improved outcomes remains limited (Brown et al., 2019; Martinez Garcia & Agulnik, 2019). These studies emphasize the need for scalability and cultural tailoring, especially in regions where healthcare staffing and infrastructure are constrained.

Several papers in this review underscored that training and adherence to PEWS protocols directly influenced its effectiveness. Tume et al. (2015) found that after formal PEWS training sessions, recognition of deterioration and preemptive ICU transfers rose by 23%. Conversely, facilities with low nurse-to-patient ratios or inadequate pediatric expertise showed weaker PEWS performance, despite using the same scoring algorithm (Maconochie et al., 2013; Cheng et al., 2022).

Implementation science plays a crucial role in successful PEWS adoption. Studies from the U.S. and U.K. (e.g., Kowalski et al., 2021; Lambert et al., 2017) suggest that PEWS integration into electronic health record (EHR) systems improves real-time monitoring, audit trails, and adherence to response protocols. When automated alerts are coupled with mandatory clinical reviews, response times for interventions such as fluid resuscitation or antibiotic administration are significantly reduced.

Another recurring theme in this review is the role of parental concern and staff intuition, which are often included as non-numeric modifiers in enhanced PEWS systems. Murray et al. (2015) and Agulnik et al. (2018) suggest that the inclusion of subjective concerns (e.g., “worried parent” flags) enhances sensitivity without compromising specificity, especially in infants and non-verbal children.

Comparative studies like that of Shanbhag et al. (2023) evaluated PEWS against other scoring tools like PAWS and found no significant difference in predictive value for ICU admissions. However, they highlighted that PEWS was easier to implement and more widely recognized, supporting its continued use as the primary triage tool in pediatric EDs. Simplicity and standardization appear to be key strengths, especially when dealing with time-sensitive emergencies.

Despite its strengths, some studies argue for caution. MacDonell et al. (2017) criticized the lack of consistent thresholds and limited high-quality evidence on mortality outcomes. Moreover, most PEWS studies are observational in nature, which introduces risks of bias. Randomized controlled trials (RCTs) in this domain are rare but necessary for conclusively determining causality between PEWS implementation and improved pediatric outcomes.

Finally, the future of PEWS likely lies in digital and AI-enhanced decision support. As seen in some reviewed studies, machine learning models trained on PEWS data improved outcome prediction by integrating vital sign trends, comorbidities, and historical EHR data (Fuijkschot et al., 2015). This layered intelligence could refine the score's precision, reduce false positives, and optimize pediatric emergency workflows across global settings.

5. CONCLUSION

This systematic review affirms the growing utility of Pediatric Early Warning Scores (PEWS) in pediatric emergency departments. When applied effectively, PEWS can significantly aid in the early identification of clinical deterioration, enabling quicker intervention and potentially saving lives. Its structured approach supports clinical decision-making and enhances communication among healthcare providers.

However, effectiveness is closely tied to local implementation practices. Settings with robust training, integrated clinical pathways, and responsive escalation protocols see the greatest benefit. PEWS alone is not a substitute for clinical judgment, and its predictive value must be interpreted alongside other clinical signs and contextual factors.

Future directions should focus on refining PEWS thresholds, improving specificity to reduce false positives, and adapting tools for low-resource settings. Digital innovations and real-time analytics could further enhance predictive accuracy, ensuring that PEWS continues to evolve as a cornerstone of pediatric emergency care.

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