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Predictive Value of Pediatric Early Warning Scores for Respiratory Deterioration in the Emergency Department: A Systematic Review

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Abstract

***Objectives*:** To assess the predictive value of Pediatric Early Warning Scores (PEWS) for identifying respiratory deterioration in children presenting to the emergency department. ***Methods*:** A thorough search across four databases identified 455 relevant publications. After removing duplicates using Rayyan QCRI and screening for relevance, 36 full-text articles were reviewed, with 5 studies ultimately meeting the criteria for inclusion. ***Results*:** We included five studies with a total of 155,836 children and 87,424 (56.1%) were males. PEWS has been demonstrated to significantly enhance clinical outcomes by enabling early recognition of patient deterioration, allowing for preemptive action. It has shown potential as a predictive tool for hospitalization, particularly in identifying children at risk of severe outcomes. PEWS also aids clinicians in prioritizing patient care, escalating care more effectively, and making informed decisions regarding the need for intensive monitoring or transfer to specialized care units. ***Conclusion*:** PEWS is a valuable tool in pediatric emergency and critical care, with significant potential to improve patient outcomes by facilitating the early detection of deterioration. However, to maximize its benefits, PEWS should be integrated into a broader clinical assessment and decision-making framework, complemented by other diagnostic indicators and clinical judgments. Future research should focus on refining the scoring system to enhance its sensitivity and specificity, tailoring its application to effectively address different pediatric conditions.

Keywords: Pediatric Early Warning Scores (PEWS), Clinical Outcomes, Hospitalization, Respiratory Affection.

INTRODUCTION

Clinical deterioration in hospitalized children typically follows periods of physiological instability that can be identified by monitoring vital signs and other clinical indicators at the bedside. Early detection allows for timely interventions that could avert serious outcomes like cardiac arrest and death. However, these early warning signs may be missed or not appropriately managed by healthcare staff [1].

PEWS are promoted as tools to help healthcare professionals identify children at risk, leading to enhanced monitoring and referral to personnel skilled in emergency and critical care [2]. Although there is no standardized definition, PEWS generally combine various vital signs and clinical indicators that signal organ dysfunction. There are primarily two types: Score-based PEWS, which evaluate clinical indicators against a scoring matrix to quantify deviations from normal ranges. High or low scores raise concerns, and the cumulative score reflects the child's overall health, indicating the level of risk for deterioration. Higher scores correlate with a greater risk [3]. Score-based PEWS typically include an escalation protocol guiding the healthcare professional's actions at each score level. Conversely, trigger-based PEWS activate upon reaching a specific threshold and are simpler as they do not require a scoring matrix or summing of indicators. The thresholds set in trigger-based PEWS are usually higher to minimize false alarms. Both systems depend on consistent patient surveillance to monitor their condition and initiate necessary actions when set criteria are met [4].

PEWS have been developed as a tool to help healthcare professionals quickly identify children who may be at risk of imminent clinical deterioration. In

emergency departments (ED), where rapid decision-making is critical, the ability to foresee respiratory deterioration can significantly influence outcomes. Despite their widespread use, the predictive accuracy of PEWS specifically for respiratory issues in the pediatric population within the ED setting remains inconsistently reported and understood. This variability necessitates a comprehensive review of the literature to evaluate the effectiveness of PEWS in predicting respiratory deterioration, which is a common and potentially life-threatening condition in children. This systematic review aims to consolidate current evidence and assess the predictive value of PEWS, thereby providing insights that could enhance clinical protocols and improve pediatric patient care in emergency settings.

The primary objective of this systematic review is to evaluate the predictive value of PEWS for identifying respiratory deterioration in children presenting to the emergency department. This review seeks to determine how effectively PEWS can forecast serious respiratory complications that may necessitate advanced interventions such as escalated respiratory support or intensive care admission. Additionally, the study aims to identify any specific components of the PEWS that are most indicative of respiratory distress, to assess the potential need for adjustments in the scoring system to increase its predictive accuracy. By achieving these aims, the review intends to contribute to the optimization of early warning systems in pediatric emergency care, ensuring better health outcomes through timely and appropriate interventions.

METHODS

This systematic review followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines [5], to ensure methodological rigor and transparency. The objective of this review was to systematically investigate the predictive value of PEWS for identifying respiratory deterioration in children presenting to the emergency department. A comprehensive search of electronic databases, including PubMed, Web of Science, SCOPUS, and Science Direct, was conducted to identify relevant English-language studies. Two independent reviewers screened the search results, selected studies that met the eligibility criteria, extracted relevant data, and assessed the quality of the included studies using standardized tools.

Eligibility Criteria

Inclusion Criteria

1. **Study Type**: Peer-reviewed research studies including randomized controlled trials, cohort studies, case-control studies, and observational studies.
2. **Participants**: Studies involving pediatric patients (aged 0-20 years) presenting to the emergency department.
3. **Intervention/Exposure**: Studies that utilize PEWS as a tool to predict respiratory deterioration.
4. **Outcome Measures**: Primary outcomes should include the efficacy of PEWS in predicting respiratory deterioration.
5. **Setting**: Studies conducted in emergency department settings.
6. **Language**: Articles published in English.

Exclusion Criteria

1. **Study Type**: Editorials, opinion pieces, reviews (systematic or narrative), and case reports.
2. **Participants**: Studies involving adult populations or those exclusively focusing on neonates (e.g., in neonatal intensive care units).
3. **Outcome Measures**: Studies focusing solely on outcomes unrelated to respiratory issues, such as cardiac events, neurological status, or general mortality without specific relevance to respiratory deterioration.
4. **Data Availability**: Studies with incomplete data or those lacking specific outcomes related to the predictive accuracy of PEWS for respiratory deterioration.
5. **Non-Emergency Settings**: Research conducted in settings other than emergency departments, such as inpatient wards or outpatient clinics.

Data Extraction

The Rayyan (QCRI) platform [6], was utilized to organize and review the search outcomes, maintaining uniformity and dependability in the selection procedure. Titles and abstracts were examined for relevance according to the established inclusion and exclusion criteria. Full-text versions of studies that appeared eligible were independently assessed by two researchers. Differences in the selection of studies or in the extraction of data were settled through discussions until a consensus was reached. A standardized data extraction form was used to collect key information, including:

- Study title, authors, and publication year
- Study location and design
- Participant demographics (e.g., age & gender)
- PEWS related data.
- Main outcomes.

Additionally, a separate tool was developed to assess the risk of bias in the included studies.

Data Synthesis Strategy

The extracted data was synthesized to create summary tables and narrative summaries, facilitating a qualitative evaluation of the findings. The synthesis focused on identifying patterns, trends, and gaps in the evidence regarding the use of PEWS in the assessment of respiratory deterioration among children.

Risk of Bias Assessment

The methodological quality of the included studies was evaluated using the Joanna Briggs Institute

(JBI) [7], critical appraisal tool for prevalence studies. This tool consists of nine questions, with each question scored as 1 (yes), 0 (no/unclear/not applicable). Studies will be categorized as follows:

- High quality: Scores of 8–9
- Moderate quality: Scores of 5–7
- Low quality: Scores below 4

Two independent reviewers assessed the quality of each study, and any disagreements were resolved through discussion. Studies deemed to have a high risk of bias was excluded from the final synthesis to ensure the reliability of the review's conclusions.

RESULTS

The specified search strategy yielded 797 publications **(Figure 1).** After removing duplicates (n = 364), 433 trials were evaluated based on title and abstract. Of these, 397 failed to satisfy eligibility criteria, leaving just 32 full-text articles for comprehensive review. A total of 7 satisfied the requirements for eligibility with evidence synthesis for analysis.

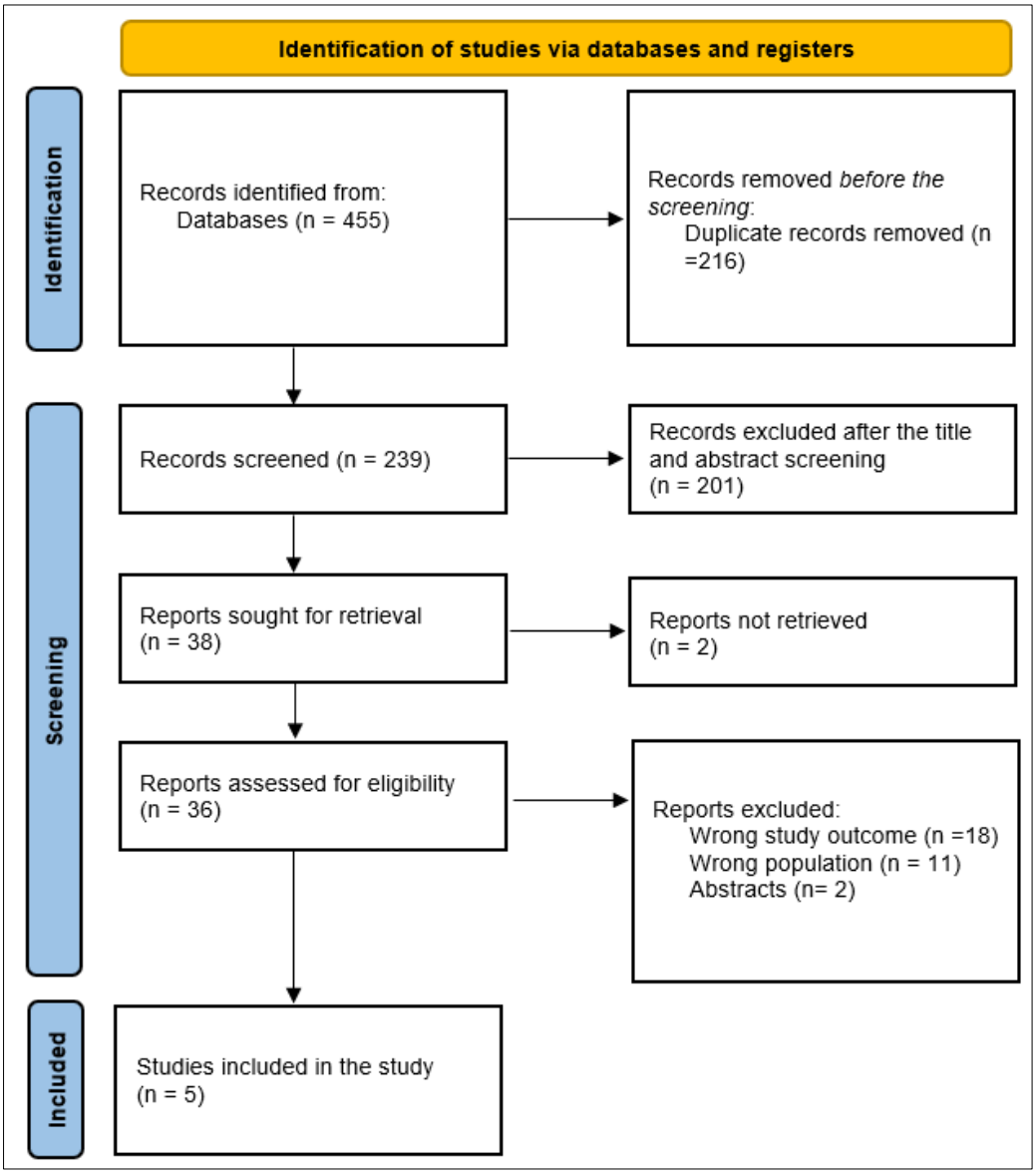

Figure 1: PRISMA flowchart [14]

Sociodemographic and Clinical Outcomes

We included five studies with a total of 155,836 children and 87,424 (56.1%) were males. Regarding study designs, three studies were retrospective cohorts [8-12], and two were prospective observational studies [9, 10]. Three studies were conducted in the USA [8-10], one in Canada [11], and one in the UK [12]. The earliest study was conducted in 2014 [9], and the latest in 2022 [12].

The findings across various studies demonstrate the diverse applications and implications of PEWS in managing pediatric health crises. In one retrospective cohort study, it was found that higher PEWS scores correlated with increased respiratory and heart rates,

suggesting that PEWS can serve as a crucial indicator of acute physiological distress that requires prompt medical attention [8].

Another study focused on the correlation of PEWS with the required level of care at emergency department dispositions, highlighting that while PEWS can indicate the need for increased care, it lacks the sensitivity and specificity to function effectively on its own. However, its diagnostic accuracy improves in cases involving respiratory issues, suggesting its potential utility in such specific scenarios [9].

A prospective observational study noted that higher PEWS scores were more common among children who required hospitalization as compared to those discharged, indicating the score's effectiveness in predicting the need for more intensive treatment and hospital admission, including to intensive care units [10].

In another context, a study examining the use of High-Flow Nasal Cannula (HFNC) therapy found that rising PEWS scores following the initiation of HFNC treatment indicated a lack of response to the therapy. This suggests that PEWS can be a valuable tool in assessing and adjusting ongoing respiratory support strategies [11].

Lastly, during a pandemic, a significant study recorded a rise in PEWS among children infected with adenovirus compared to pre-pandemic levels, pointing out the specific impact of viral infections on early warning scores. This was notable as the only significant variation observed, emphasizing PEWS's role in monitoring disease severity during epidemic outbreaks [12].

Table 1: Outcome measures of the included studies

Study ID	Country	Study design	Sociodemographic	Applying PEWS	Mean PEWS	Main outcomes	JBI
Kowalski *et al*., 2021 [8]	USA	Retrospective cohort	Cases: 72 Median age: 2.3 Males: 33 (45.8%)	56 (78%)	2.2 ± 2.4	Higher PEWS scores, associated with increased respiratory and heart rates	6
Breslin *et al*., 2014 [9]	USA	Prospective observational study	Cases: 383 Age range: 0-21 Males: 211 (55.1%)	383 (100%)	NM	The PEWS correlates with the level of care required at Emergency Department disposition but lacks sufficient sensitivity and specificity to be used alone. Its diagnostic performance is improved in patients presenting with respiratory issues.	7
Kessler *et al*., 2022 [10]	USA	Prospective observational study	Cases: 85 Median age: 2.2 Males: 48 (56.5%)	85 (85%)	Median: 1 IQR: 2	RPEWS is higher in children who are hospitalized compared to those who are discharged home, indicating that a higher RPEWS is associated with a greater likelihood of hospital admission, including admission to intensive care units.	7
Hansen *et al*., 2019 [11]	Canada	Retrospective cohort	Cases: 240 Mean age: 2.42 Males: 122 (61.9%)	240 (100%)	2.4 ± 0.5	Elevated and increasing PEWS scores 90 minutes after starting High-Flow Nasal Cannula (HFNC) therapy, when used alongside a standard ward HFNC	7

						protocol for respiratory distress, may suggest a lack of response to the treatment.	
Lumley *et al*., 2022 [12]	UK	Retrospective cohort	Cases: 155,056 Age range: 0-15 Males: 87,010 (56.1%)	NM	NM	During the pandemic, attendees with adenovirus exhibited higher PEWS compared to pre-pandemic levels (p = 0.04), with no other significant differences in PEWS observed.	7

DISCUSSION

The PEWS system is a critical tool in pediatric emergency and critical care settings, primarily aimed at detecting early signs of clinical deterioration to enable timely intervention. The studies reviewed collectively highlight the broad utility of PEWS across different scenarios, from predicting the need for hospital admission to evaluating the effectiveness of respiratory therapies such as HFNC. However, the variability in its sensitivity and specificity, particularly when used as a standalone measure, underscores the complexity of implementing PEWS in a clinical setting. The adaptability of PEWS in response to specific conditions, like respiratory ailments during pandemics, provides a promising avenue for targeted clinical application.

When used as a solitary measure, there is minimal evidence to suggest that PEWS significantly impact critical patient outcomes like mortality, unplanned transfers to pediatric intensive care units, or adverse events such as cardiac and respiratory arrests. However, the scenario changes when PEWS is part of a broader intervention strategy that includes educational components and access to specialist teams equipped to address emerging critical conditions in children. In such contexts, there is moderate evidence indicating that PEWS can help reduce mortality rates and decrease the occurrence of cardiorespiratory arrests. Nonetheless, the strength of this evidence is limited, primarily stemming from observational studies. Furthermore, while most research on PEWS has been conducted in specialist pediatric hospitals, there is a scarcity of studies exploring its effectiveness in non-acute settings [13, 14].

Chong *et al.*, acknowledged that their findings did not show a definitive advantage of systems using PEWS in reducing mortality, cardiopulmonary arrest, or critical deterioration events [15]. However, the lack of observed effect does not rule out the potential benefits of incorporating PEWS into a clinical response system designed to improve early detection and intervention in deteriorating children. Future research should concentrate on a forward-looking assessment of PEWS, with precise recording of interventions carried out for patients at risk of decompensation due to specific causes such as respiratory, circulatory, or neurological issues [16].

Tibballs *et al*., showed that the implementation of a Medical Emergency Team (MET) service not only decreased the incidence of preventable cardiac arrests but also improved survival rates from unforeseen cardiac arrests in hospital wards [17]. In a separate study, while there was no notable decrease in mortality rates, the introduction of PEWS along with a clinical response system was associated with a decrease in the need for invasive ventilation during Pediatric Intensive Care Unit (PICU) admissions and resulted in shorter durations of stay in the PICU [18].

PEWS can significantly enhance clinical outcomes by facilitating early recognition of deterioration, thereby allowing for preemptive action to prevent severe complications such as cardiac arrest or death. Clinicians can leverage PEWS to prioritize patient care, escalate care more effectively, and make informed decisions about the need for intensive monitoring or transfer to specialized care units. The utility of PEWS in assessing response to treatments like HFNC also suggests its role in guiding clinical decisions during ongoing therapeutic interventions.

Strengths

One of the primary strengths highlighted by the studies is the potential of PEWS to serve as a predictive tool for hospitalization, particularly in identifying children at risk of severe outcomes. Its application across diverse clinical scenarios, including routine emergency care and specialized treatments like HFNC therapy, also illustrates its versatility. Additionally, the use of PEWS during pandemic conditions to monitor disease severity indicates its adaptability to varied clinical challenges.

Limitations

Despite its strengths, the application of PEWS also presents limitations. The lack of uniformity in sensitivity and specificity across different clinical settings suggests that PEWS may not always provide reliable indicators of deterioration without supplementary clinical judgments and additional diagnostic tools. Furthermore, the variability in the

effectiveness of PEWS based on the type of medical condition (e.g., respiratory vs. non-respiratory illnesses) indicates that its predictive power might be constrained by the specific clinical contexts in which it is used.

CONCLUSION

PEWS is a valuable tool in the pediatric emergency and critical care toolkit, offering significant potential to improve patient outcomes by facilitating early detection of deterioration. Its predictive value in assessing the severity of illness and the effectiveness of treatments like HFNC underscores its utility in complex clinical scenarios. However, to fully leverage PEWS's benefits, it should be integrated into a broader clinical assessment and decision-making framework, complemented by other diagnostic indicators and clinical judgments. Future research should aim to refine the scoring system, enhance its sensitivity and specificity, and tailor its application to maximize its effectiveness across different pediatric conditions.

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