REVIEW ARTICLE

TOOLS FOR EARLY DETECTION OF CLINICAL DETERIORATION AND PREVENTION OF CARDIORESPIRATORY ARREST: AN INTEGRATIVE REVIEW

Mariane Ferreira Lopes[1]; Lucas da Silva Alves[2]
Maíza Ferreira dos Santos[3]; Mariana Cristina dos Santos Souza[4]
Bárbara de Caldas Melo[5]; Breno de Sousa Santana[6]

Highlights: (1) NEWS and MEWS reduce severe events and enhance patient safety. (2) Early warning tools effectively detect clinical deterioration. (3) Score implementation supports rapid decisions and saves lives in hospitals.

PRE-PROOF
(as accepted)
This is a preliminary and unedited version of a manuscript accepted for publication in *Revista Contexto & Saúde*. As a service to our readers, we are providing this initial version of the manuscript as accepted. The article will still undergo review, formatting, and author approval before being published in its final form.

http://dx.doi.org/10.21527/2176-7114.2025.50.13957

How to cite:
Lopes MF, Alves L da S, dos Santos MF, Souza MC dos S, Melo B de C, Santana B de S. Tools for early detection of clinical deterioration and prevention of cardiorespiratory arrest: an integrative review. Rev. Contexto & Saúde. 2025;25(50):e13957

[1] Centro Universitário do Distrito Federal - UDF. Brasília/DF, Brazil. https://orcid.org/0000-0001-9202-1746
[2] Centro Universitário do Distrito Federal - UDF. Brasília/DF, Brazil. https://orcid.org/0000-0003-4054-4953
[3] Centro Universitário do Distrito Federal - UDF. Brasília/DF, Brazil. https://orcid.org/0000-0003-4465-7234
[4] Centro Universitário do Distrito Federal - UDF. Brasília/DF, Brazil. https://orcid.org/0000-0002-0304-4813
[5] Centro Universitário do Distrito Federal - UDF. Brasília/DF, Brazil. https://orcid.org/0000-0003-4465-7234
[6] Centro Universitário do Distrito Federal - UDF. Brasília/DF, Brazil. https://orcid.org/0000-0002-4899-5209

TOOLS FOR EARLY DETECTION OF CLINICAL DETERIORATION AND PREVENTION OF CARDIORESPIRATORY ARREST: AN INTEGRATIVE REVIEW

ABSTRACT

This study aims to identify tools for the early detection of clinical deterioration and their usability in preventing cardiopulmonary arrest. It is an integrative literature review conducted in the Medical Literature Analysis and Retrieval System Online (MEDLINE), Latin American and Caribbean Literature in Health Sciences (LILACS), and Nursing Database (BDENF). A total of 242 articles were identified, of which 12 were selected for descriptive synthesis. Most publications occurred between 2015 and 2022, with a peak in 2021 (33.3%). The most represented countries were the United States, the United Kingdom, and Taiwan, with the National Early Warning Score (NEWS) being the most frequently used tool (33.3%). All studies demonstrated that early warning tools, such as NEWS and MEWS, were effective in preventing adverse events, including cardiorespiratory arrest and death. Thus, it is concluded that the use of clinical deterioration detection tools is applicable in various hospital settings and can support the identification of cardiorespiratory arrest and other adverse events, contributing to improved patient safety and the quality of healthcare.

Keywords: Cardiorespiratory Arrest; Early Warning Score; Clinical Deterioration.

INTRODUCTION

Since the publication of the report *To Err is Human: Building a Safer Health System*, a landmark document in studies on patient safety[1], this topic has emerged as a major global concern, becoming a fundamental principle in healthcare with a direct impact on the quality of care[2]. In this context, as pathological processes worsen and are accompanied by clinical deterioration, the complexity of care, along with the need for professional training, clinical reasoning, critical thinking, and diagnostic skills, is also intensified[3].

In hospital settings where patients often experience severe events, such as in critical and semi-critical care units, the role of the multidisciplinary team becomes essential. Caring for critically ill patients requires agility, skill, precise decision-making, and the ability to detect deterioration in a timely manner to enable early interventions[4-6].

Clinical deterioration is a prevalent problem in healthcare units and can be defined as a severe physiological disturbance or sudden worsening of a patient's condition, leading to acute signs and symptoms and, consequently, organ dysfunction[7]. As it is a progressive,

predictable, and symptomatic event, often reflected in changes in vital signs, managing clinical deterioration is an integral part of healthcare, with emphasis on hemodynamic monitoring and the use of advanced technologies and equipment[8].

Such changes can be recognized early through the accurate measurement and interpretation of vital signs, enabling rapid interventions to halt clinical worsening and prevent serious events such as cardiac arrest (CA) and death[9]. In this context, CA is an extremely severe condition, defined as the sudden loss of blood circulation and pulmonary oxygenation with consequent cellular and tissue ischemia, characterized by mechanical cardiac failure and manifested by unresponsiveness, absence of effective breathing, and lack of detectable central pulse[10].

The signs of acute illness are similar regardless of the underlying process, as they reflect alterations in the respiratory, cardiac, and neurological systems. Physiological changes in one or more parameters are associated with a greater likelihood of severe events. Understanding that clinical deterioration is gradual and progressive makes it possible to anticipate and prevent CA in critically ill patients[8].

Decreased level of consciousness or acute confusion, hypoxia, tachycardia, hypotension, tachypnea, and abnormal temperature are clinical manifestations associated with deterioration and increased risk of mortality, and they may be present up to eight hours before CA[11]. A study conducted at a university hospital found that approximately 79% of patients who experienced cardiac arrest exhibited significant changes in vital signs, and 54% of these patients subsequently died, highlighting the importance of routine vital sign monitoring in hospital settings[12].

Recognition of this problem in healthcare institutions has led to the adoption of strategies aimed at reducing its impact, such as the development of rapid response systems/teams (RRS) that facilitate the early recognition and appropriate response to clinical deterioration[8]. In this regard, early interventions carried out by RRS can become more efficient with the implementation of early warning scores, which assign points to alterations in physiological parameters that are easily measurable at the bedside.

To identify patients with acute clinical deterioration early and accurately, the concept of Early Warning Scores (EWS) was proposed by Morgan and colleagues in 1997. These

scores are simple tools that assess physiological patterns and can be used at the bedside to evaluate the risk of clinical deterioration and alert healthcare teams to the need for closer monitoring of the patient's condition[13].

Building on Morgan's concept, many variations of Early Warning Scores have been implemented both in Brazil and worldwide. It is considered essential to review these variations in order to assist healthcare professionals in determining which score best fits their clinical reality and, thus, facilitate decision-making and care planning. In this context, this study aims to identify tools for the early detection of clinical deterioration and their usability in preventing cardiac arrest (CA).

METHOD

This is an integrative literature review, whose construction process was structured in six stages: (1) formulation of the research question; (2) definition of databases and inclusion and exclusion criteria; (3) definition of the information to be extracted from the selected studies; (4) evaluation of the included studies; (5) interpretation of the results; and (6) synthesis of knowledge[14].

To formulate the research question, the PICO acronym[15] was used, with P (Population) = critically ill adult patients hospitalized with acute clinical deterioration; I (Intervention) = tools for early identification of acute clinical deterioration; C (Comparison) = not applicable; and O (Outcome) = early detection and prevention of cardiac arrest (CA). Thus, the guiding research question was: "Can tools for the early detection of acute clinical deterioration help prevent cardiac arrest in critically ill adults?".

The inclusion criteria were primary articles published between 2012 and 2023, in English, Spanish, or Portuguese, whose population consisted of critically ill adult patients with acute conditions and hospitalized in any unit. Dissertations, theses, and literature reviews were excluded.

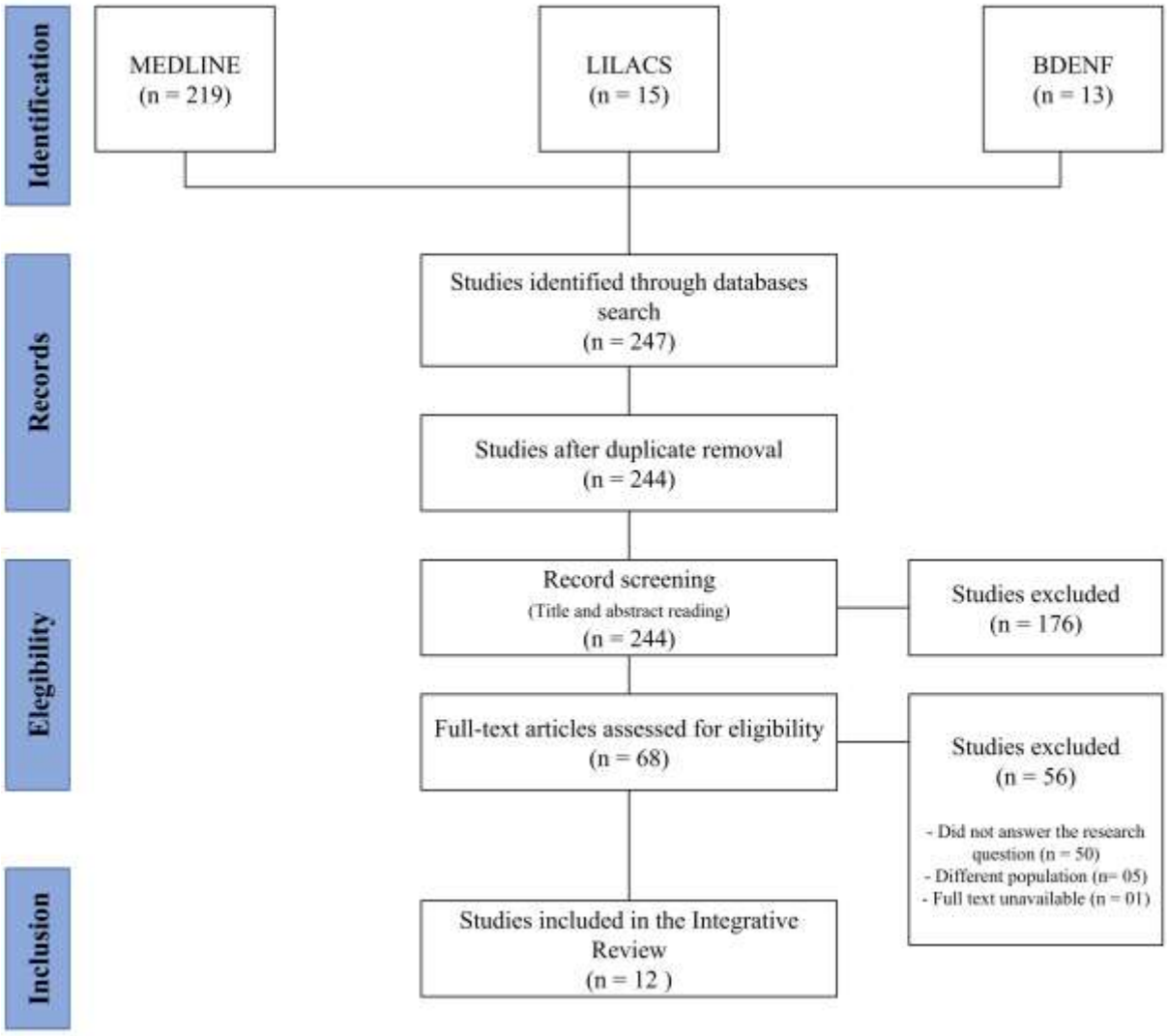
The databases used for this review were Medical Literature Analysis and Retrieval System Online (MEDLINE), Latin American and Caribbean Literature in Health Sciences (LILACS), and Nursing Database (BDENF), all accessed through the Virtual Health Library (BVS).

To systematize the search, the following portuguese *Descritores em Ciências da Saúde* (DeCS) and Medical Subject Headings (MeSH) were used: *Parada Cardiorrespiratória* or Cardiorespiratory Arrest; *Deterioração Clínica* or Clinical Deterioration; *Escore de Alerta Precoce* or Early Warning Score; *Quadros Agudos* or Acute Disease. The search strategy used in the databases was: (("*Deterioração Clínica*") OR ("Clinical Deterioration") AND ("*Parada Cardiorrespiratória*") OR ("Cardiorespiratory Arrest")) AND (("*Escore de Alerta Precoce*") OR ("Early Warning Score") AND ("*Cuidados Críticos*") OR ("Critical Care")).

The search was carried out in August 2022, resulting in 219 studies in MEDLINE, 15 in LILACS, and 13 in BDENF, totaling 247 studies. The references were compiled and exported to the Rayyan tool[16], with an initial removal of three duplicates and a paired review of the titles and abstracts of the remaining 244 studies. After evaluating the primary articles, data were extracted from the studies that answered the guiding research question. Data extraction was performed using a structured data collection instrument developed by the authors and organized in a Microsoft Office Excel 365® spreadsheet, with the following variables: authors, article title, journal, year of publication, language, country of publication, study objective, design, tool used for clinical deterioration assessment, results, conclusion, and recommendations. After completing the spreadsheet, the data were compiled, reviewed, and presented descriptively.

After the initial review of titles and abstracts, 68 articles were selected for the next stage, which consisted of full-text reading. Of these, 12 articles were included in this integrative review, and 56 were excluded for the reasons specified in Figure 1.

Figure 1. Flowchart of identification, screening, eligibility, and inclusion of articles in the integrative review. Brasília, DF, Brazil, 2022.



Note: MEDLINE = Medical Literature Analysis and Retrieval System Online; LILACS = Latin American and Caribbean Literature in Health Sciences; BDENF = Nursing Database. **Source:** Prepared by the authors, based on the PRISMA Guideline[17].

RESULTS

Of the 12 studies included in the review, publications ranged from 2015 to 2022, with the highest number published in 2021 (33.3%). In addition, the studies originated from the United States (n = 3; 25%), the United Kingdom (n = 2; 16.7%), and Taiwan (n = 2; 16.7%).

Brazil, India, Egypt, Hong Kong, and Italy were also represented, each accounting for 8.3%. The journal with the highest number of publications was *Critical Care Medicine* (n = 2; 16.7%) (Table 1).

Table 1. Characterization of the articles included in the Integrative Review (n = 12).

Authors / Year	Article Title	Journal, Language, and Country
Su et al., 2022[18]	Improved Inpatient Deterioration Detection in General Wards by Using Time-Series Vital Signs	Research Square English, Taiwan
Akel et al., 2021[19]	Less is More: Detecting Clinical Deterioration in the Hospital with Machine Learning Using Only Age, Heart Rate, and Respiratory Rate	Resuscitation English, USA
Badr et al., 2021[20]	Effect of National Early Warning Scoring System Implementation on Cardiopulmonary Arrest, Unplanned ICU Admission, Emergency Surgery, and Acute Kidney Injury in an Emergency Hospital, Egypt	Journal of Multidisciplinary Healthcare – Dovepress English, Egypt
Bhatnagar et al., 2021[21]	Prediction of hospital outcome in emergency medical admissions using modified early warning score (MEWS): Indian experience	Journal of Family Medicine and Primary Care English, India
Pimentel et al., 2021[22]	Detecting Deteriorating Patients in the Hospital. Development and Validation of a Novel Scoring System	American Journal of Respiratory and Critical Care Medicine English, UK
Wu et al., 2021[23]	Implementation of an Electronic National Early Warning System to Decrease Clinical Deterioration in Hospitalized Patients at a Tertiary Medical Center.	International Journal of Environmental Research and Public Health English, Taiwan
Shamout et al., 2020[24]	Deep Interpretable Early Warning System for the Detection of Clinical Deterioration	Journal of Biomedical and Health Informatics English, UK
Bedoya et al., 2019[25]	Minimal Impact of Implemented Early Warning Score and Best Practice Alert for Patient Deterioration	Critical Care Medicine English, USA
Spagnolli et al., 2017[26]	Application of the National Early Warning Score (NEWS) as a stratification tool on admission in an Italian acute medical ward: A perspective study	The International Journal of Clinical Practice English, Italy
Montenegro & Miranda, 2019[27]	*Avaliação do desempenho do escore de alerta precoce modificado em hospital público brasileiro*	Revista Brasileira de Enfermagem (REBEn) Portuguese, Brazil
Kang et al.,	Real-Time Risk Prediction on the Wards: A	Critical Care Medicine

2016[28]	Feasibility Study	English, USA
So et al., 2015[29]	Is the Modified Early Warning Score able to enhance clinical observation to detect deteriorating patients earlier in an Accident & Emergency Department?	Australasian Emergency Care English, Hong Kong

Source: Prepared by the authors.

All studies had a quantitative design, with retrospective cohort and prospective observational methods being the most common, each represented by two articles (16.7%). Regarding the application of tools, the National Early Warning Score (NEWS) was the most frequently used (n = 4; 33.3%), followed by its modified version, the Modified Early Warning Score (MEWS) (n = 3; 25%) (Table 2).

The primary studies included aimed to demonstrate that it is possible to predict adverse events through the use of tools that evaluate vital signs to identify alterations, such as systolic blood pressure, respiratory rate, heart rate, temperature, oxygen saturation, and supplemental oxygen (Table 2).

All articles showed significant results in the early detection of clinical deterioration, including unplanned ICU admissions, CA, and death, thereby demonstrating the applicability of these scores in the clinical care context (Table 2).

Table 2. Characterization of early detection tools for clinical deterioration and their usability for preventing cardiac arrest

Authors / Year	Early detection tools for cardiac arrest	Usability for preventing cardiac arrest
Su et al., 2022[18]	TEWS	The TEWS model detected more cases of deterioration with the same level of specificity as other algorithms, suggesting it may be an alternative method for identifying patient deterioration.
Akel et al., 2021[19]	eCART Lite	eCART Lite significantly outperformed MEWS, NEWS, and eCART v2 in predicting ICU transfers and composite outcomes. Respiratory rate and heart rate were two of the strongest predictors. Using only three variables, a tool was developed to predict clinical deterioration with accuracy comparable to or greater than commonly used

Authors / Year	Early detection tools for cardiac arrest	Usability for preventing cardiac arrest
		algorithms, with potential for use in settings with limited resources or where low-cost tools are required.
Badr et al., 2021[20]	NEWS	There was a significant reduction in cardiac arrests, unplanned ICU admissions, emergency surgeries, and acute kidney injuries. NEWS implementation was associated with improved patient outcomes in hospital wards, increased frequency of vital sign measurements, and a higher number of medical reviews following clinical instability.
Bhatnagar et al., 2021[21]	MEWS	A MEWS score > 5 within 24 hours of admission was significantly associated with in-hospital mortality, being an effective predictor with 78% sensitivity and 94% specificity. Thus, MEWS application in medical emergency units can be a useful tool to enhance patient care, ensure optimal resource utilization, and prevent inappropriate discharges or neglect of severely ill patients.
Pimentel et al., 2021[22]	HAVEN	With 10% precision, HAVEN identified 42% of cardiac arrests or unplanned ICU admissions up to 48 hours in advance. The HAVEN machine learning algorithm for early detection of hospital deterioration significantly outperformed other published scores, such as NEWS.
Wu et al., 2021[23]	E-NEWS	CPRs on wards were significantly reduced through the use of E-NEWS, a computerized system that updates NEWS automatically every hour.
Shamout et al., 2020[24]	DEWS	DEWS achieved greater accuracy than NEWS and state-of-the-art performance, even with a limited set of resources. DEWS reduced the number of triggers compared to NEWS, particularly among younger patients. It also performed better on the composite outcome and the three individual outcomes (unplanned ICU admission, cardiac arrest, and mortality).
Bedoya et al., 2019[25]	NEWS	The primary outcome of ICU transfer or death did not change after NEWS implementation. Retraining NEWS with hospital-specific

Authors / Year	Early detection tools for cardiac arrest	Usability for preventing cardiac arrest
		coefficients improved model performance. Both in academic and community hospitals, NEWS had poor performance characteristics and was often ignored by frontline nursing staff. Consequently, NEWS implementation did not have a notable impact on defined clinical outcomes. Adjusting the model using local data improved performance and supports the validation of predictive models with site-specific data.
Spagnolli et al., 2017[26]	NEWS	For patients with NEWS > 4 vs. NEWS < 4, the risk of early death increased from 12 to 36 times, total mortality from 3.5 to 9, and urgent transfers from 3.5 to 7. Among patients with sudden cardiac events, lower scores were significantly associated with a higher risk of transfer to higher-intensity care. In patients with chronic hypoxemia, adverse outcomes were less frequent in the medium and high NEWS score categories.
Montenegro & Miranda, 2019[27]	MEWS	An increasing number of combined events were observed as the score value increased. MEWS ≥ 4 was the most appropriate cutoff for predicting these events. MEWS accurately measures the occurrence of severe events in patients hospitalized in a Brazilian public hospital ward. MEWS ≥ 4 appears to be the most suitable cutoff for predicting these events.
Kang et al., 2016[28]	eCART	During the study period, 8/10 patients with cardiac arrest had high-risk eCART scores, while the RRS was activated in only 2 of these cases. Additionally, eCART identified 52% of ICU transfers compared to 34% by the current system. Patients reached the high-risk eCART threshold a median of 30 hours before cardiac arrest or ICU transfer, compared to 1.7 hours with standard rapid response team activation. eCART identified significantly more cardiac arrests and ICU transfers than standard RRS activation.
So et al., 2015[29]	MEWS	Respiratory rate was a significant vital sign for

Authors / Year	Early detection tools for cardiac arrest	Usability for preventing cardiac arrest
		detecting patient deterioration. The use of MEWS for patient monitoring did not significantly improve detection of deterioration among patients waiting for admission beds in a public emergency department. However, MEWS may be beneficial for less experienced nurses to identify patient deterioration.

Note: TEWS = Time Series Early Warning Score; MEWS = Modified Early Warning Scores; DEWS = Deep Early Warning System; NEWS = National Early Warning Score; E-NEWS = On-line Electronic NEWS System; eCART Lite = electronic Cardiac Arrest Risk Triage; HAVEN = Hospital-wide Alerting via Electronic Noticeboard System. **Fonte:** Prepared by the authors.

Four of the six instruments used (TEWS, MEWS, DEWS, and NEWS) are manually completed scales, while the other three (E-NEWS, eCART Lite, and HAVEN) are electronic and automated, providing real-time results. In addition to these data, the methodology employed by each of these scores can be found in Table 3.

Quadro 3. Tools used for early detection of clinical deterioration and prevention of cardiac arrest.

Tools	**Usability**
electronic Cardiac Arrest Risk Triage (eCART)	eCART Lite uses three parameters as predictive features: age, heart rate, and respiratory rate, which can be extracted in real time from patient monitors[19,28].
Time Series Early Warning Score (TEWS)	TEWS uses five vital signs as predictive features: systolic blood pressure, diastolic blood pressure, heart rate, respiratory rate, and body temperature[18].
National Early Warning Score (NEWS)	NEWS uses seven vital signs as predictive features: systolic blood pressure, respiratory rate, heart rate, temperature, oxygen saturation, supplemental oxygen, and level of consciousness[20,25,26].
Modified Early Warning Scores (MEWS)	MEWS uses five vital signs as predictive features: temperature, heart rate, systolic blood pressure, respiratory rate, and level of consciousness[21,27,29].
Hospital-wide Alerting via Electronic Noticeboard System (HAVEN)	HAVEN provides a real-time risk assessment that is continuously updated using patient vital signs, laboratory test results, and medical history[22].
On-line Electronic NEWS System (E-NEWS)	E-NEWS uses seven vital signs as predictive features: systolic blood pressure, respiratory rate, heart rate, temperature, oxygen saturation, supplemental oxygen, and level of consciousness. In its electronic version, scores are automatically calculated every hour[23].
Deep Early Warning System (DEWS)	DEWS uses seven vital signs as predictive features: systolic blood pressure, respiratory rate, heart rate, temperature, oxygen saturation, supplemental oxygen, and level of consciousness[24].

Source: Prepared by the authors.

DISCUSSION

This study presented the use of tools designed for the early recognition of clinical deterioration in hospitalized patients as a preventive measure for severe events, particularly cardiac arrest (CA). The analysis of the articles revealed that systematized tools play a key role in risk management, facilitating the identification of physiological changes and significantly reducing the likelihood of CA, unplanned ICU admissions, and death.

An important initiative was carried out in the United Kingdom in 2012, aiming to improve the assessment and documentation of vital signs in hospital settings. This led to the introduction of the National Early Warning Score (NEWS), a unified and standardized concept at the national level. Since then, early warning scoring systems have been adopted as

objective methods to identify patient deterioration and ensure timely interventions[29]. This review found that three authors focused their studies on the applicability and outcomes of NEWS[20,25,26], while another author developed and applied an electronic version of the score[23].

Brazilian studies indicate that clinical deterioration is often identified late in hospital units, which may expose patients to inadequate or delayed treatment, compromising both safety and the quality of care[27,30].

This review showed that tools such as NEWS, TEWS, MEWS, and DEWS have the potential to prevent or identify adverse events. These simple and versatile tools are based on scores assigned to changes in physiological parameters, such as systolic blood pressure, respiratory rate, heart rate, temperature, oxygen saturation, supplemental oxygen, and level of consciousness[18,20,21,24–27,29].

Evidence indicates that more than 60% of primary adverse events, including death, CA, and unplanned ICU transfers, are preceded by confirmed abnormalities in physiological parameters. The implementation of evidence-based interventions, such as the systematization of clinical processes and early recognition of clinical deterioration, is considered an international priority[28].

Understanding how to better organize the care flow for critically ill patients through evidence-based interventions, including the systematization of clinical processes, early recognition, and treatment of patients in deterioration, is an international priority[28].

Although the primary articles included in this review highlighted the positive effects of clinical deterioration tools worldwide, there is a notable scarcity of Brazilian studies, particularly those that emphasize the use of these tools by healthcare professionals working in Brazilian hospitals.

To automate the process and avoid human errors, systems such as E-NEWS and eCART Lite have emerged, which also use scores based on altered vital signs but in an electronic manner, automatically calculating the scores every hour[20-22]. In addition, HAVEN stands out for incorporating laboratory test results and medical history alongside vital signs, enabling a more precise interpretation and offering a broader clinical perspective[29].

A study conducted by Kang and colleagues in 2016 in the United States found that eight out of ten patients who progressed to CA had high-risk eCART scores. eCART

identified significantly more cardiac arrests and ICU transfers than the scores most commonly used by rapid response teams in the United States, indicating that it may be a promising alternative as a predictor of adverse events[28].

Based on electronic medical records, continuous risk score curves can be used to monitor subtle variations in vital signs and successfully predict clinical deterioration in general wards. To reduce staff workload and enable immediate early detection of clinical deterioration, automated calculations based on electronic medical record data are urgently needed[20].

This study emphasizes, through the results of the selected articles, that the use of early deterioration tools effectively identifies adverse events, allowing the multidisciplinary team to take early and precise actions. Furthermore, these tools significantly improve the quality of information during inter-team communication, facilitating decision-making and consequently contributing to better healthcare services.

Algumas limitações devem ser consideradas frente aos resultados apresentados aqui. Some limitations should be considered regarding the results presented here. First, the heterogeneity of the studies included in this review hinders the establishment of causal relationships between the data obtained from the scores and the occurrence of CA and other adverse events. The scarcity of high-level evidence studies, such as randomized clinical trials and quasi-experimental studies, was also a limiting factor that supports this observation. Moreover, the difficulty in finding Brazilian studies (only one was identified) imposes restrictions on the generalization of the results of this review to the national reality.

Recognizing that the methodological quality of the reviewed studies varies considerably is essential, as some feature more robust designs, while others used observational approaches. Despite this variation, the convergence of results regarding the benefits of early detection tools for clinical deterioration suggests consistency in the evidence, strengthening confidence in the conclusions.

Although some limitations exist, the results of this review are promising. While there is no national standardization regarding the use of early detection tools for clinical deterioration, the positive effects and significant improvements observed after implementing these scores are undeniable.

Given the importance of interprofessional care for patients, especially in hospital settings, the implementation of early warning and rapid response systems to detect clinical deterioration is essential. This review highlights several alternatives that can be considered and adapted to the specific needs of each healthcare institution.

However, it is important that the adoption of these systems is not arbitrary. It is recommended that healthcare service management teams develop strategies to choose the most appropriate approach, considering the challenges faced by the entire healthcare team, and not only nursing professionals. This may require investment in continuing education programs to ensure proper adherence and effective use of these systems.

CONCLUSION

Based on the findings of this review, it is evident that the most widely used tools for the early detection of clinical deterioration in hospitalized patients include NEWS, MEWS, TEWS, and DEWS. These tools have been consistently associated with a reduced likelihood of severe events, such as CA, unplanned intensive care unit admissions, and death.

Furthermore, the results highlight the effective usability of these tools in preventing CA and other serious adverse events. The implementation of these early warning systems has proven to facilitate the identification of early signs of clinical deterioration, enabling timely interventions that can save lives and improve patient outcomes.

In light of these findings, further studies are recommended to investigate the comparative effectiveness of different tools for the early detection of clinical deterioration, as well as their adaptation and application across various healthcare settings. Such research can contribute to improving clinical practices and enhancing patient safety in hospital environments.

REFERENCES

1. Kohn LT, Corrigan JM, Donaldson MS. To Err Is Human: building a safer health system [Internet]. 1st ed. Washington, D.C.: Committee on Quality of Health Care in America; 2000. 287 p. Available from: https://www.ncbi.nlm.nih.gov/books/NBK225182/

2. Albalawi A, Kidd L, Cowey E. Factors contributing to the patient safety culture in Saudi

Arabia: a systematic review. BMJ Open [Internet]. 2020 Oct 14;10(10):e037875. Available from: https://bmjopen.bmj.com/lookup/doi/10.1136/bmjopen-2020-037875

3. Xavier DM, Vettorello JS, Galvão DM, Redü A de O, Martins CF, Cezar-Vaz MR. Raciocínio Clínico no trabalho do enfermeiro: dificuldades, fragilidades e estratégias em unidades de internação hospitalar. Res Soc Dev [Internet]. 2022 Sep 22;11(12):e502111234812. Available from: https://rsdjournal.org/index.php/rsd/article/view/34812

4. Velasco-Sanz TR, Rayón-Valpuesta E. Instrucciones previas en cuidados intensivos: competencias de los profesionales sanitarios. Med Intensiva [Internet]. 2016 Apr;40(3):154–62. Available from: https://dx.doi.org/10.1016/j.medin.2015.04.011

5. Daly KJ, Camporota L, Barrett NA. An international survey: the role of specialist nurses in adult respiratory extracorporeal membrane oxygenation. Nurs Crit Care [Internet]. 2017 Sep;22(5):305–11. Available from: https://onlinelibrary.wiley.com/doi/10.1111/nicc.12265

6. Camelo SHH. Professional competences of nurse to work in Intensive Care Units: an integrative review. Rev Lat Am Enfermagem [Internet]. 2012 Feb;20(1):192–200. Available from: https://doi.org/10.1590/S0104-11692012000100025

7. Al-Moteri M, Plummer V, Cooper S, Symmons M. Clinical deterioration of ward patients in the presence of antecedents: A systematic review and narrative synthesis. Aust Crit Care [Internet]. 2019 Sep;32(5):411–20. Available from: https://doi.org/10.1016/j.aucc.2018.06.004

8. Freitas C, Preto E, Nascimento C. Nursing interventions for the early detection of ward patients' clinical deterioration: an integrative review. Rev Enferm Ref [Internet]. 2017 Sep 29;IV Série(Nº14):121–32. Available from: https://doi.org/10.12707/RIV17025

9. Lott C, Truhlář A, Alfonzo A, Barelli A, González-Salvado V, Hinkelbein J, et al. European Resuscitation Council Guidelines 2021: Cardiac arrest in special circumstances. Resuscitation [Internet]. 2021 Apr;161:152–219. Available from: https://dx.doi.org/10.1016/j.resuscitation.2021.02.011

10. Panchal AR, Bartos JA, Cabañas JG, Donnino MW, Drennan IR, Hirsch KG, et al. Part 3: Adult Basic and Advanced Life Support: 2020 American Heart Association Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care. Circulation [Internet]. 2020 Oct 20;142(16_suppl_2):S366–468. Available from: https://www.ahajournals.org/doi/10.1161/CIR.0000000000000916

11. Xiong W, Lu L, Zhang B, Luo J, Li W, He L, et al. Association of consciousness impairment and mortality in people with COVID-19. Acta Neurol Scand [Internet]. 2021 Sep 24;144(3):251–9. Available from: https://onlinelibrary.wiley.com/doi/10.1111/ane.13471

12. Nascimento JDSG, Macedo GDO, Borges GB. Poder preditivo de uma escala de alerta precoce para deterioração clínica de pacientes críticos. Rev Enferm da UFSM [Internet]. 2020

Jan 8;10:e5. Available from: https://periodicos.ufsm.br/reufsm/article/view/38300

13. Oliveira APA de, Urbanetto J de S, Caregnato RCA. National Early Warning Score 2: transcultural adaptation to Brazilian Portuguese. Rev Gaúcha Enferm [Internet]. 2020;41:15. Available from: https://dx.doi.org/10.1590/1983-1447.2020.20190424

14. Whittemore R, Knafl K. The integrative review: updated methodology. J Adv Nurs [Internet]. 2005 Dec;52(5):546–53. Available from: http://doi.wiley.com/10.1111/j.1365-2648.2005.03621.x

15. Santos CMDC, Pimenta CADM, Nobre MRC. The PICO strategy for the research question construction and evidence search. Rev Lat Am Enfermagem [Internet]. 2007 Jun;15(3):508–11. Available from: https://doi.org/10.1590/S0104-11692007000300023

16. Ouzzani M, Hammady H, Fedorowicz Z, Elmagarmid A. Rayyan—a web and mobile app for systematic reviews. Syst Rev [Internet]. 2016 Dec 5;5(1):210. Available from: http://dx.doi.org/10.1186/s13643-016-0384-4

17. Moher D, Liberati A, Tetzlaff J, Altman DG. Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA Statement. PLoS Med [Internet]. 2009 Jul 21;6(7):e1000097. Available from: https://dx.plos.org/10.1371/journal.pmed.1000097

18. Su C-F, Chiu S-I, Jang J-SR, Lai F. Improved inpatient deterioration detection in general wards by using time-series vital signs. Sci Rep [Internet]. 2022 Dec 13;12(1):11901. Available from: https://dx.doi.org/10.1038/s41598-022-16195-2

19. Akel MA, Carey KA, Winslow CJ, Churpek MM, Edelson DP. Less is more: Detecting clinical deterioration in the hospital with machine learning using only age, heart rate, and respiratory rate. Resuscitation [Internet]. 2021 Nov;168(773):6–10. Available from: https://dx.doi.org/10.1016/j.resuscitation.2021.08.024

20. Badr M, Khalil N, Mukhtar A. Effect of National Early Warning Scoring System Implementation on Cardiopulmonary Arrest, Unplanned ICU Admission, Emergency Surgery, and Acute Kidney Injury in an Emergency Hospital, Egypt. J Multidiscip Healthc [Internet]. 2021 Jun;Volume 14:1431–42. Available from: https://dx.doi.org/10.2147/JMDH.S312395

21. Bhatnagar M, Sirohi N, Dubey A. Prediction of hospital outcome in emergency medical admissions using modified early warning score (MEWS): Indian experience. J Fam Med Prim Care [Internet]. 2021;10(1):192. Available from: https://dx.doi.org/10.4103/jfmpc.jfmpc_1426_20

22. Pimentel MAF, Redfern OC, Malycha J, Meredith P, Prytherch D, Briggs J, et al. Detecting Deteriorating Patients in the Hospital: Development and Validation of a Novel Scoring System. Am J Respir Crit Care Med [Internet]. 2021 Jul 1;204(1):44–52. Available from: https://dx.doi.org/10.1164/rccm.202007-2700OC

23. Wu C-L, Kuo C-T, Shih S-J, Chen J-C, Lo Y-C, Yu H-H, et al. Implementation of an Electronic National Early Warning System to Decrease Clinical Deterioration in Hospitalized Patients at a Tertiary Medical Center. Int J Environ Res Public Health [Internet]. 2021 Apr 25;18(9):4550. Available from: https://dx.doi.org/10.3390/ijerph18094550

24. Shamout FE, Zhu T, Sharma P, Watkinson PJ, Clifton DA. Deep Interpretable Early Warning System for the Detection of Clinical Deterioration. IEEE J Biomed Heal Informatics [Internet]. 2020 Feb;24(2):437–46. Available from: https://dx.doi.org/10.1109/JBHI.2019.2937803

25. Bedoya AD, Clement ME, Phelan M, Steorts RC, O'Brien C, Goldstein BA. Minimal Impact of Implemented Early Warning Score and Best Practice Alert for Patient Deterioration. Crit Care Med [Internet]. 2019 Jan;47(1):49–55. Available from: http://journals.lww.com/00003246-201901000-00007

26. Spagnolli W, Rigoni M, Torri E, Cozzio S, Vettorato E, Nollo G. Application of the National Early Warning Score (NEWS) as a stratification tool on admission in an Italian acute medical ward: A perspective study. Int J Clin Pract [Internet]. 2017 Mar;71(3–4):e12934. Available from: https://dx.doi.org/10.1111/ijcp.12934

27. Montenegro SMSL, Miranda CH. Evaluation of the performance of the modified early warning score in a Brazilian public hospital. Rev Bras Enferm [Internet]. 2019 Dec;72(6):1428–34. Available from: https://dx.doi.org/10.1590/0034-7167-2017-0537

28. Kang MA, Churpek MM, Zadravecz FJ, Adhikari R, Twu NM, Edelson DP. Real-Time Risk Prediction on the Wards. Crit Care Med [Internet]. 2016 Aug;44(8):1468–73. Available from: http://journals.lww.com/00003246-201608000-00003

29. So S-N, Ong C-W, Wong L-Y, Chung JYM, Graham CA. Is the Modified Early Warning Score able to enhance clinical observation to detect deteriorating patients earlier in an Accident & Emergency Department? Australas Emerg Nurs J [Internet]. 2015 Feb;18(1):24–32. Available from: https://dx.doi.org/10.1016/j.aenj.2014.12.001

30. Al-Moteri M, Plummer V, Cooper S. Decision-Making Errors During Recognizing and Responding to Clinical Deterioration: Gaze Path-Cued Retrospective Think-Aloud. Clin Simul Nurs [Internet]. 2022 Dec;73(2015):29–36. Available from: https://doi.org/10.1016/j.ecns.2022.08.002

Submitted: January 31, 2023

Accepted: March 14, 2025

Published: August 6. 2025

TOOLS FOR EARLY DETECTION OF CLINICAL DETERIORATION AND PREVENTION OF CARDIORESPIRATORY ARREST: AN INTEGRATIVE REVIEW

Authors' Contributions	
Mariane Ferreira Lopes:	Conceptualization; Data curation; Formal analysis; Investigation; Methodology; Validation; Visualization; Writing – original draft; Writing – review & editing.
Lucas da Silva Alves:	Conceptualization; Data curation; Formal analysis; Investigation; Methodology; Validation; Visualization; Writing – original draft; Writing – review & editing.
Maíza Ferreira dos Santos:	Conceptualization; Data curation; Formal analysis; Investigation; Methodology; Validation; Visualization; Writing – original draft; Writing – review & editing.
Mariana Cristina dos Santos Souza:	Formal analysis; Writing – original draft; Writing – review & editing.
Bárbara de Caldas Melo:	Formal analysis; Writing – original draft; Writing – review & editing.
Breno de Sousa Santana:	Conceptualization; Data curation; Formal analysis; Investigation; Methodology; Project administration; Supervision; Validation; Visualization; Writing – original draft; Writing – review & editing.
All authors approved the final version of the manuscript.	
Conflict of Interest:	There are no conflicts of interest.
Funding:	This study received no funding.
Corresponding Author:	Breno de Sousa Santana Centro Universitário do Distrito Federal – UDF SEP/SUL EQ704/904 Conjunto A Brasília/DF, Brazil – Zip code: 70390-045 bresousas@outlook.com

TOOLS FOR EARLY DETECTION OF CLINICAL DETERIORATION AND PREVENTION OF CARDIORESPIRATORY ARREST: AN INTEGRATIVE REVIEW