# MODIFICATIONS TO MET CALL CRITERIA

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## QUESTION

What parameters could safely reduce medical emergency team (MET) calls, without harming patients? Are there any particular groups of patients where MET call criteria can be safely modified, or are there any particular conditions where MET call criteria can be safely modified?

## RESULTS

### PEER-REVIEWED LITERATURE – MOST RECENT FIRST

Articles are grouped as follows:

- Impact of modifications on patient safety & outcomes *(pp. 1-3)*
- Parameters for specific cohorts *(pp. 3-5)*
- Comparisons of calling criteria & policies *(pp. 5-6)*
- Use of additional parameters *(pp. 6-7)*
- Artificial intelligence models – parameters provided *(pp. 7-9)*
- Review articles on rapid response systems *(pp. 9-10)*

*Each article summary contains excerpts from the abstract and an online link.*

## IMPACT OF MODIFICATIONS ON PATIENT SAFETY & OUTCOMES

S. R. Baylis, et al. (2024). **Frequency of and associations with alterations of medical emergency team calling criteria in a teaching hospital emergency department**. *Australian critical care : official journal of the Confederation of Australian Critical Care Nurses*, *37*(2), 301-308. Click to read full-text.
The objectives of this study were to (i) describe the frequency of altered calling criteria (ACC) in a teaching hospital ED and the number and type of vital signs that were modified and (ii) associations between ACC in the ED and differences in the baseline patient characteristics and adverse outcomes including subsequent MET activations, unplanned intensive care unit (ICU) admissions and death within 72 h of admission. METHOD(S): Retrospective observational study of patients presenting to an academic, tertiary hospital ED in Melbourne, Australia between January 1st, 2019 and December 31st, 2019. RESULT(S): Amongst 14 159 ED admissions, 725 (5.1%) had ACC, most frequently for increased heart or respiratory rate. ACC was associated with older age and increased comorbidity. Such patients had a higher adjusted risk of MET activation, unplanned ICU admission, and death within 72 h. CONCLUSION(S): ACC occurs commonly in the ED, most frequently for elevated heart and respiratory rates and is associated with worse patient outcomes.

R. M. Chinthamuneedi, et al. (2023). **Modifications to rapid response team (medical emergency team) activation criteria and its impact on patient safety**. *Internal Medicine Journal*, *53*(7), 1212-1217. Click to read full-text.
Aim(s): To evaluate the effectiveness of RRT activation criteria modifications in preventing RRT activation and differences in adverse events associated with treatment delays caused by modifications. Method(s): A prospective chart audit of hospital patients with RRT activation criteria modifications admitted during a 12-month period in a large regional hospital in Toowoomba,

Australia. Result(s): A total of 271 patients out of 4009 admitted patients had modifications to their RRT activation criteria. There was no difference in rates of RRT activation in patients with modified criteria compared with patients with unmodified criteria (P = 0.37). In patients with RRT activation criteria modifications, rates of adverse events were higher in patients who met their modified RRT criteria (93.3%) compared with those who did not meet modified RRT criteria (3.8%; P < 0.001). Additionally, in patients with modifications, rates of adverse events were higher in medical patients (27.6%; n = 50) compared with surgical patients (15.6%; n = 14; P = 0.03). Conclusion(s): The results strongly suggest that RRT criteria modification is associated with no difference in rates of RRT activation and with detrimental impacts on patient safety, particularly in medical patients.

S. K. Sprogis, et al. (2021). **Modifications to medical emergency team activation criteria and implications for patient safety: A point prevalence study**. *Australian critical care : official journal of the Confederation of Australian Critical Care Nurses*, *34*(6), 580-586. Click to read full-text.
The aim of the study was to examine the safety of modifying MET activation criteria. Specifically, we aimed to examine the frequency and nature of modifications to MET activation criteria and compare characteristics and outcomes of patients with and without modifications to MET activation criteria. METHOD(S): This was a point prevalence study using a retrospective medical record audit. Patients admitted to 14 wards on November 7, 2018, at two acute-care hospitals of one health service in Melbourne, Australia, were included (N = 430). RESULT(S): Amongst 430 inpatients, there were 30 modifications to MET activation criteria in 26 (6.0%) patients. All modifications were intended to trigger METs at more extreme levels of physiological derangement. Most modifications pertained to tachypnoea (26.7%; n = 8/30) and bradycardia (23.3%; n = 7/30). CONCLUSION(S): In this point prevalence study, modifications to MET activation criteria were infrequent and not associated with negative patient safety outcomes.

S. Crouch, et al. (2021). **The use of altered rapid response calling criteria in a tertiary referral facility**. *Australian critical care : official journal of the Confederation of Australian Critical Care Nurses*, *34*(3), 204-208. Click to read full-text.
The purpose of this study was to examine the current utilisation of altered rapid response calling criteria (ARRCCs) at a tertiary hospital. METHOD(S): A retrospective review of all acute care admissions across 17 months was undertaken using the hospital administration system and electronic medical record to identify patients with ARRCCs. RESULT(S): The total hospital admissions numbered 45 912, with ARRCCs used in 768 (1.7%). Patients with an ARRCC during hospital admission were older (68.5 vs 59.0 years) and had a significantly longer length of hospital stay (6.9 vs 2 days). Compared with the total group of patient admissions, patients with ARRCCs more frequently triggered a rapid response team (9.0% vs 14.2%), more frequently suffered a cardiac arrest (0.2 vs 0.9%), more frequently died in the hospital (p < 0.001), and were less frequently discharged home. CONCLUSION(S): Patients with an ARRCC stayed longer in the hospital and were at increased risk of cardiac arrest and death during hospitalisation. Further exploration of the role of ARRCCs in facilitating individualised care to meet the needs and treatment goals of each patient in the acute hospital setting is required.

T. Kerkham, et al. (2020). **Rapid response team trigger modifications: are we using them safely?**. *Internal Medicine Journal, 50*. 1513-1517. Click to read full-text.
Aims: To determine if RRT trigger modifications are associated with: increased frequency of recurrent RRT activation; increased length of stay (LOS); increased intensive care admission; and increased in-hospital mortality. Methods: A retrospective audit of all RRT activations occurring at the Launceston General Hospital (LGH) over an 18-month period was performed. Results: Rate of recurrent RRT activations did not decrease with the use of trigger modifications around the time of

RRT activation, and for patients with two modifications, the frequency increased (1.98 vs 1.32). LGH LOS increased for patients with any trigger modifications compared to those with none (11 vs 9), and for patients with two modifications (11.5 vs 9). Total hospital LOS increased for patients with any modifications compared to patients with none (12 vs 10). Conclusions: Trigger modifications are associated with increased hospital LOS and increased rate of in-hospital death and do not reduce the number of recurrent events. For patients in whom escalation of care is not appropriate, the presence of multiple trigger modifications at the time of an RRT activation may be a useful trigger for conversations around goals of care.

A. Ganju, et al. (2019). **Modifications to predefined rapid response team calling criteria: prevalence, characteristics and associated outcomes**. *Critical care and resuscitation : journal of the Australasian Academy of Critical Care Medicine*, *21*(1), 32-38. Click to read full-text.
Little data are available regarding the efficacy or safety of modifying RRT calling criteria; therefore, this study aimed to detail the prevalence and characteristics of modifications to RRT call triggers and explore their relationship with patient outcomes. DESIGN: A pilot retrospective cohort study within a convenience sample of patients attended by a hospital RRT between July and December 2014. RESULT(S): During the study period, 673 patients had RRT calls, of whom 620 (91.2%) had data available for analysis. The majority of study patients (393; 63.4%) had modifications documented. Patients with modifications were more likely to have repeat RRT calls and experience in-hospital mortality versus patients without modifications. In the secondary analyses, although all classes of modification had higher rates of repeat calling, none reached statistical significance. Mortality was associated with having modifications that were more conservative than the standard calling criteria.

*Note: Supported by letter from Monash Health-affiliated researcher who undertook a smaller study at Cabrini –* LETTER: Modifications to predefined rapid response team calling criteria: prevalence, characteristics and associated outcomes (2020)

## PARAMETERS FOR SPECIFIC COHORTS

A. M. Pirret, et al. (2022). **Removing modifications to the New Zealand Early Warning Score- does ethnicity matter? A multimethod research design**. *Intensive & critical care nursing*, *68*, 103141. Click to read full-text.
BACKGROUND: Previous research on a modified New Zealand Early Warning Score (M-NZEWS) used in predominately medical ward patients identified removing the modifications would significantly reduce the number of M-NZEWSs triggering the medical emergency team (MET), particularly in Maori patients. AIM: To firstly, explore the impact of removing the modifications from the M-NZEWS on medical and surgical ward patients' early warning score MET triggers and secondly, determine if the M-NZEWS MET triggers resulted in MET activations and if the MET activations were a result of M-NZEWS MET triggers. CONCLUSION(S): Removing the modifications would significantly reduce the number of MET triggers, particularly in Maori patients. Analysing solely electronic vital sign data may not reflect the number of medical emergency team triggers or activations.

*Note: 'Implications for Practice' section discusses impact of altered calling criteria.*

M. Drake, et al. (2021). **Introduction of a standardised maternity early warning system: Indicative data from a before-and-after study at a large pilot site before national rollout in Aotearoa New Zealand**. *Anaesthesia*, *76*(12), 1600-1606. Click to read full-text.
In Aotearoa New Zealand, following the nationwide implementation of the standardised New Zealand Early Warning Score (NZEWS) for adult inpatients, a modified maternity-specific variation (NZMEWS) was piloted in a major tertiary hospital in Auckland, before national rollout. Following

implementation in July 2018, we observed a significant and sustained reduction in severe maternal morbidity as measured by emergency response calls to women who were very unwell (emergency response team call), and a non-significant reduction in cardiorespiratory arrest team calls. Emergency response team calls to maternity wards fell from a median of 0.8 per 100 births at baseline (January 2017-May 2018) to 0.6 per 100 births monthly (from March 2019 to December 2020) (p < 0.0001). …These early results provide evidence that NZMEWS can detect and prevent deterioration of pregnant women, although there are multiple factors that may have contributed to the reduction in emergency response calls noted.

J. R. Lee, et al. (2020). **Derivation and validation of modified early warning score plus SpO2/FiO2 score for predicting acute deterioration of patients with hematological malignancies**. *Korean Journal of Internal Medicine*, *35*(6), 1477-1488. Click to read full-text.
We evaluated the modified early warning score (MEWS) for predicting ICU admissions and in-hospital mortality among at-risk patients with hematological malignancies and developed an optimized MEWS. Method(s): We retrospectively analyzed derivation cohort patients with hematological malignancies who were managed by a medical emergency team (MET) in the general ward and prospectively validated the data. We compared the traditional MEWS with the MEWS plus SpO2/FiO2 (MEWS_SF) score, which were calculated at the time of MET contact. Conclusion(s): Compared to the traditional MEWS, the MEWS_SF score may be a useful tool that can be used in the general ward to identify deteriorating patients with hematological malignancies.

M. Capan, et al. (2017). **A stochastic model of acute-care decisions based on patient and provider heterogeneity**. *Health care management science*, *20*(2), 187-206. Click to read full-text.
Identifying acute physiologic deterioration (APD) is difficult, and response timing is critical - delays in response represent a significant and modifiable patient safety issue. Hospitals have instituted rapid response systems or teams (RRT) to provide timely critical care for APD, with thresholds that trigger the involvement of critical care expertise. The National Early Warning Score (NEWS) was developed to define these thresholds. However, current triggers are inconsistent and ignore patient-specific factors. Further, acute care is delivered by providers with different clinical experience, resulting in quality-of-care variation. This article documents a semi-Markov decision process model of APD that incorporates patient and provider heterogeneity. The model allows for stochastically changing health states, while determining patient subpopulation-specific RRT-activation thresholds. …This study provides simple practical rules for personalized acute care delivery.

A. C. Quinn, et al. (2016). **Obstetric early warning systems to prevent bad outcome**. *Current Opinion in Anaesthesiology*, *29*(3), 268-272. Click to read full-text.
In the UK, a National Early Warning Score was launched in 2013 and is now used throughout the National Health Service. In 2007, a firm recommendation was made by the maternal confidential death enquiry that maternity units should incorporate a modified early obstetric warning score chart into clinical practice. Although there was enthusiastic uptake of this recommendation, local recording systems vary throughout the country and there is now a need to revisit revise and standardize an obstetric early warning system (ObsEWS). The intercollegiate Maternal Critical Care group of the Obstetric Anaesthetists' Association have produced an ObsEWS in line with the aggregate UK National Early Warning Score. Six physiological parameters are incorporated: respiratory rate, oxygen saturations, temperature, systolic blood pressure, diastolic blood pressure, and pulse rate. However, robust physiological thresholds for the measured parameters are currently lacking but required for a more sensitive and specific ObsEWS.

## COMPARISONS OF CALLING CRITERIA & POLICIES

M. Green, et al. (2018). **Comparison of the Between the Flags calling criteria to the MEWS, NEWS and the electronic Cardiac Arrest Risk Triage (eCART) score for the identification of deteriorating ward patients**. *Resuscitation*, *123*, 86-91. Click to read full-text.
OBJECTIVE: We sought to compare the Between the Flags (BTF) calling criteria to the Modified Early Warning Score (MEWS), National Early Warning Score (NEWS) and electronic Cardiac Arrest Risk Triage (eCART) score. DESIGN: Multicenter retrospective analysis of electronic health record data from all patients admitted to five US hospitals from November 2008-August 2013. RESULTS: Overall accuracy was highest for eCART, with an AUC of 0.801 (95% CI 0.799-0.802), followed by NEWS, MEWS and BTF respectively (0.718 [0.716-0.720]; 0.698 [0.696-0.700]; 0.663 [0.661-0.664]). CONCLUSION: An electronically generated eCART score was more accurate than commonly used paper based observation tools for predicting the composite outcome of in-hospital cardiac arrest, ICU transfer and death within 24 h of observation. The outcomes of this analysis lend weight for a move towards an algorithm based electronic risk identification tool for deteriorating patients to ensure earlier detection and prevent adverse events in the hospital.

J. Considine, et al. (2018). **Comparison of policies for recognising and responding to clinical deterioration across five Victorian health services**. *Australian health review : a publication of the Australian Hospital Association*, *42*(4), 412-419. Request the full-text.
The aim of the present study was to describe and compare organisational guidance documents related to recognising and responding to clinical deterioration across five health services in Victoria, Australia. METHODS: Guidance documents were obtained from five health services, comprising 13 acute care hospitals, eight subacute care hospitals and approximately 5500 beds. RESULTS: In all, 22 guidance documents and five graphic observation and response charts were reviewed. Variation was observed in terminology, content and recommendations between the health services. RRS activation criteria varied between sites, with all sites requiring modifications to RRS activation criteria to be made by medical staff. …A better understanding of the relationship between the sensitivity, specificity and frequency of monitoring of particular physiological observations and patient outcomes is needed to improve the predictive validity for identification of clinical deterioration. *Note: Full-text includes comparison table of activation criteria at each health service.*

S. Yu, et al. (2014). **Comparison of risk prediction scoring systems for ward patients: A retrospective nested case-control study**. *Critical Care*, *18*(3), R132. Click to read full-text.
This study compares the ability of nine risk prediction scores in detecting clinical deterioration among non-ICU ward patients. We also measured each score serially to characterize how these scores changed with time. Method(s): In a retrospective nested case-control study, we calculated nine well-validated prediction scores for 328 cases and 328 matched controls. Our cohort included non-ICU ward patients admitted to the hospital with a diagnosis of infection, and cases were patients in this cohort who experienced clinical deterioration, defined as requiring a critical care consult, ICU admission, or death. We then compared each prediction score's ability, over the course of 72 hours, to discriminate between cases and controls. Conclusion(s): ICU- and emergency room-based prediction scores can also be used to prognosticate risk of clinical deterioration for non-ICU ward patients. In addition, scoring models that take advantage of a score's change over time may have increased prognostic value over models that use only a single set of physiologic measurements.

## USE OF ADDITIONAL PARAMETERS

F. Haegdorens, et al. (2024). **Combining the Nurse Intuition Patient Deterioration Scale with the National Early Warning Score provides more Net Benefit in predicting serious adverse events: A**

**prospective cohort study in medical, surgical, and geriatric wards**. *Intensive & critical care nursing*, *83*, 103628. Click to read full-text.
This prospective cohort study aimed to assess the predictive value of the Nurse Intuition Patient Deterioration Scale (NIPDS) combined with the National Early Warning Score (NEWS) for identifying serious adverse events in patients admitted to diverse hospital wards. METHODOLOGY/DESIGN: Data was collected between December 2020 and February 2021 in a 350-bed acute hospital near Brussels, Belgium. The study followed a prospective cohort design, employing NIPDS alongside NEWS for risk assessment. Patients were monitored for 24 h post-registration, with outcomes recorded. RESULT(S): In a cohort of 313 patients, 10/313 and 31/313 patients reached the primary and secondary outcome respectively. For the primary outcome, NIPDS had a sensitivity of 0.900 and specificity of 0.927, while NEWS had a sensitivity of 0.300 and specificity of 0.974.

*Related:* Predicting patient deterioration by nurse intuition: The development and validation of the nurse intuition patient deterioration scale (2023)

G. Douw, et al. (2017). **Capturing early signs of deterioration: The dutch-early-nurse-worry-indicator-score and its value in the rapid response system**. *Journal of Clinical Nursing*, *26*(17-18), 2605-2613. Click to read full-text.
Background: Dutch-early-nurse-worry-indicator-score comprises nine indicators underlying nurses' 'worry' about a patient's condition. All indicators independently show significant association with unplanned intensive care/high dependency unit admission or unexpected mortality. Prediction of this outcome improved by adding the dutch-early-nurse-worry-indicator-score indicators to an Early Warning Score based on vital signs. Design: An observational cohort study was conducted on three surgical wards in a tertiary university-affiliated teaching hospital. …Entering all dutch-early-nurse-worry-indicator-score indicators in a multiple logistic regression analysis, we calculated a weighted score and calculated sensitivity, specificity, positive predicted value and negative predicted value for each possible total score. Conclusions: Dutch-early-nurse-worry-indicator-score indicators alert in an early stage of deterioration, before reaching the trigger threshold to call a rapid response team.

M. M. Churpek, et al. (2016). **The value of vital sign trends for detecting clinical deterioration on the wards**. *Resuscitation*, *102*, 1-5. Click to read full-text.
Early detection of clinical deterioration on the wards may improve outcomes, and most early warning scores only utilize a patient's current vital signs. The added value of vital sign trends over time is poorly characterized. We investigated whether adding trends improves accuracy and which methods are optimal for modelling trends. Method(s): Patients admitted to five hospitals over a five-year period were included in this observational cohort study, with 60% of the data used for model derivation and 40% for validation. Conclusion(s): Vital sign trends increased the accuracy of models designed to detect critical illness on the wards. Our findings have important implications for clinicians at the bedside and for the development of early warning scores.

## ARTIFICIAL INTELLIGENCE MODELS – PARAMETERS PROVIDED

B. D. Steitz, et al. (2024). **Development and Validation of a Machine Learning Algorithm Using Clinical Pages to Predict Imminent Clinical Deterioration**. *Journal of General Internal Medicine*, *39*(1), 27-35. Click to read full-text.
Objective(s): Develop a machine learning algorithm using pager messages sent between clinical team members to predict imminent clinical deterioration. Design(s): We conducted a large observational study using long short-term memory machine learning models on the content and frequency of clinical pages. Participant(s): We included all hospitalizations between January 1, 2018 and December 31, 2020 at Vanderbilt University Medical Center that included at least one page message

to physicians. Main Measures: Model classification performance to identify in-hospital cardiac arrest, transfer to intensive care, or Rapid Response activation in the next 3-, 6-, and 12-hours. We compared model performance against three common early warning scores: Modified Early Warning Score, National Early Warning Score, and the Epic Deterioration Index. Key Results: The machine learning model accurately identified 62% of deterioration events within 3-hours prior to the event and 47% of events within 12-hours. Across each time horizon, the model surpassed performance of the best early warning score.

M. M. Churpek, et al. (2024). **Multicenter Development and Prospective Validation of eCARTv5: A Gradient Boosted Machine Learning Early Warning Score**. *medRxiv*. Click to view full-text. Objective(s): To develop a gradient boosted machine model (eCARTv5) for identifying clinical deterioration and then validate externally, test prospectively, and evaluate across patient subgroups. Method(s): All adult patients hospitalized on the wards in seven hospitals from 2008-2022 were used to develop eCARTv5, with demographics, vital signs, clinician documentation, and laboratory values utilized to predict intensive care unit transfer or death in the next 24 hours. The model was externally validated retrospectively in 21 hospitals from 2009-2023 and prospectively in 10 hospitals from February to May 2023. Conclusion(s): We developed eCARTv5, which accurately identifies early clinical deterioration in hospitalized ward patients. Our model performed better than the NEWS and MEWS retrospectively, prospectively, and across a range of subgroups.

R. E. Ko, et al. (2023). **Deep Learning-Based Early Warning Score for Predicting Clinical Deterioration in General Ward Cancer Patients**. *Cancers*, *15*(21), 5145. Click to read full-text. This study was conducted to develop a deep learning-based early warning score (EWS) for cancer patients (Can-EWS) using delta values in vital signs. Method(s): A retrospective cohort study was conducted on all oncology patients who were admitted to the general ward between 2016 and 2020. Result(s): During the study period, 19,739 cancer patients were admitted to the general wards and eligible for this study. Clinical deterioration occurred in 894 cases. We developed two models: Can-EWS V1, which used input vectors of the original five input variables, and Can-EWS V2, which used input vectors of 10 variables (including an additional five delta variables). Can-EWS V2 outperformed other approaches for specificities, positive predictive values, negative predictive values, and the number of false alarms per day at the same sensitivity level on the held-out test data. Conclusion(s): We have developed and validated a deep learning-based EWS for cancer patients using the original values and differences between consecutive measurements of basic vital signs. The Can-EWS has acceptable discriminatory power and sensitivity, with extremely decreased false alarms compared with MEWS.

Y. J. Lee, et al. (2021). **A multicentre validation study of the deep learning-based early warning score for predicting in-hospital cardiac arrest in patients admitted to general wards**. *Resuscitation*, *163*, 78-85. Click to read full-text. The recently developed deep learning (DL)-based early warning score (DEWS) has shown potential in predicting deteriorating patients. We aimed to validate DEWS in multiple centres and compare the prediction, alarming and timeliness performance with the modified early warning score (MEWS) to identify patients at risk for in-hospital cardiac arrest (IHCA). Method/research design: This retrospective cohort study included adult patients admitted to the general wards of five hospitals during a 12-month period. Result(s): The study population consists of 173,368 patients (224 IHCAs). The predictive performance of DEWS was superior to that of MEWS in both the internal and external validation cohorts. At the same specificity, DEWS had a higher sensitivity than MEWS, and at the

same sensitivity, DEWS reduced the mean alarm count by nearly half of MEWS. Additionally, DEWS was able to predict more IHCA patients in the 24-0.5 h before the outcome, and DEWS was reasonably calibrated. Conclusion(s): Our study showed that DEWS was superior to MEWS in three key aspects (IHCA predictive, alarming, and timeliness performance).

*Related: Earlier single-centre studies validating DEWS –*

- [Detecting Patient Deterioration Using Artificial Intelligence in a Rapid Response System (2020)](#)
- [An Algorithm Based on Deep Learning for Predicting In-Hospital Cardiac Arrest (2018)](#)

A. Kia, et al. (2020). **MEWS++: Enhancing the Prediction of Clinical Deterioration in Admitted Patients through a Machine Learning Model**. *Journal of Clinical Medicine, 9*(2), 343. [Click to read full-text.](#)
We describe a machine learning model called MEWS++ that enables the identification of patients at risk of escalation of care or death six hours prior to the event. A retrospective single-center cohort study was conducted from July 2011 to July 2017 of adult (age > 18) inpatients excluding psychiatric, parturient, and hospice patients. Three machine learning models were trained and tested: random forest (RF), linear support vector machine, and logistic regression. We compared the models' performance to the traditional Modified Early Warning Score (MEWS) using sensitivity, specificity, and Area Under the Curve for Receiver Operating Characteristic (AUC-ROC) and Precision-Recall curves (AUC-PR). The primary outcome was escalation of care from a floor bed to an intensive care or step-down unit, or death, within 6 h. The RF model had the best performance... Compared to traditional MEWS, sensitivity increased 37%, specificity increased 11%, and AUC-ROC increased 14%. This study found that using machine learning and readily available clinical data, clinical deterioration or death can be predicted 6 h prior to the event.

## REVIEW ARTICLES ON RAPID RESPONSE SYSTEMS

*Please note: The following articles do not represent an exhaustive list of all systematic reviews on rapid response systems, but rather those which met the current search criteria.*

B. D. Winters, et al. (2023). **Failure To Rescue - Rapid Response Systems: Rapid Review.** In *Making Healthcare Safer IV: A Continuous Updating of Patient Safety Harms and Practices*. U.S. Agency for Healthcare Research and Quality. [Click to read full-text.](#)
Our main objectives were to determine the effectiveness of rapid response systems on patient safety and clinical outcomes and how rapid response systems can be implemented effectively. FINDINGS: We retrieved 867 citations, of which 23 articles were eligible for review (4 systematic reviews and 19 primary studies). Three categories of interventions were identified: implementation of a new system, modifications to the afferent limb, and modifications to the efferent limb. Modifications to the afferent and/or efferent limb were associated with a reduction in mortality and the incidence of cardiorespiratory arrest for adults (low strength of evidence) but the evidence was insufficient in pediatric populations. Serious adverse events (e.g., arrest soon after ICU arrival) were infrequently reported (insufficient strength of evidence for both adult and pediatric populations). One included systematic review of the unintended consequences of staffing models examined risks for ICU patients, but the strength of evidence was insufficient for both children and adults.

J. McGaughey, et al. (2021). **Early warning systems and rapid response systems for the prevention of patient deterioration on acute adult hospital wards**. *Cochrane Database of Systematic Reviews*,

11). Click to read full-text.

Objectives: To determine the effect of EWS and RRS implementation on adults who deteriorate on acute hospital wards compared to people receiving hospital care without EWS and RRS in place. Authors' conclusions: Given the low-to-very low certainty evidence for all outcomes from non-randomised studies, we have drawn our conclusions from the randomised evidence. This evidence provides low-certainty evidence that EWS and RRS may lead to little or no difference in hospital mortality, unplanned ICU admissions, length of hospital stay or adverse events; and moderate-certainty evidence of little to no difference on composite outcome. The evidence from this review update highlights the diversity in outcome selection and poor methodological quality of most studies investigating EWS and RRS. As a result, no strong recommendations can be made regarding the effectiveness of EWS and RRS based on the evidence currently available.

L. I . Veldhuis, et al. (2022). **Artificial Intelligence for the Prediction of In-Hospital Clinical Deterioration: A Systematic Review**. *Critical Care Explorations, 4*(9), e0744. Click to read full-text.

OBJECTIVES: To analyze the available literature on the performance of artificial intelligence-generated clinical models for the prediction of serious life-threatening events in non-ICU adult patients and evaluate their potential clinical usage. DATA SYNTHESIS: In total, 45 articles were included for analysis, in which multiple methods of artificial intelligence were used. Twenty-four articles described models for the prediction of mortality and 21 for clinical deterioration. Due to heterogeneity of study characteristics (patient cohort, outcomes, and prediction models), meta-analysis could not be performed. CONCLUSIONS: Currently, a growing number of studies develop and analyzes artificial intelligence-based prediction models to predict critical illness and deterioration. We show that artificial intelligence-based prediction models have an overall good performance in predicting deterioration of patients. However, external validation of existing models and its performance in a clinical setting is highly recommended.

M. E. B. Smith, et al. (2014). **Early warning system scores for clinical deterioration in hospitalized patients: a systematic review**. *Annals of the American Thoracic Society*, *11*(9), 1454-65. Click to read full-text.

OBJECTIVE: To systematically review the evidence on the ability of early warning system scores to predict a patient's risk of clinical deterioration and the impact of early warning system implementation on health outcomes and resource utilization. MEASUREMENTS AND MAIN RESULTS: Of 11,183 citations studies reviewed, one controlled trial and 20 observational studies of 13 unique models met our inclusion criteria. CONCLUSIONS: Early warning system scores perform well for prediction of cardiac arrest and death within 48 hours, although the impact on health outcomes and resource utilization remains uncertain, owing to methodological limitations.

## APPENDIX

## SEARCH METHODOLOGY

A systematic search was conducted for literature. The results were screened by librarians using Covidence.

### SEARCH LIMITS
- Adult acute setting only
- Published within the last 10 years (2014 – Current)
- Focus on studies from countries with comparable health systems
- Systematic reviews and RCTs prioritised where available

### DATABASES SEARCHED
- Medline – index of peer-reviewed articles across health sciences and medicine.
- Embase – index of biomed and pharmacological peer reviewed journal articles.
- Emcare – index of nursing, allied health, critical-care medicine and more.
- APA PsycINFO – index of behavioural and social sciences research.
- Cochrane Library – collection of databases containing high-quality independent evidence.

### ADDITIONAL SEARCHING
- AI-enhanced citation searching was completed using LitMaps.

## SEARCH TERMS

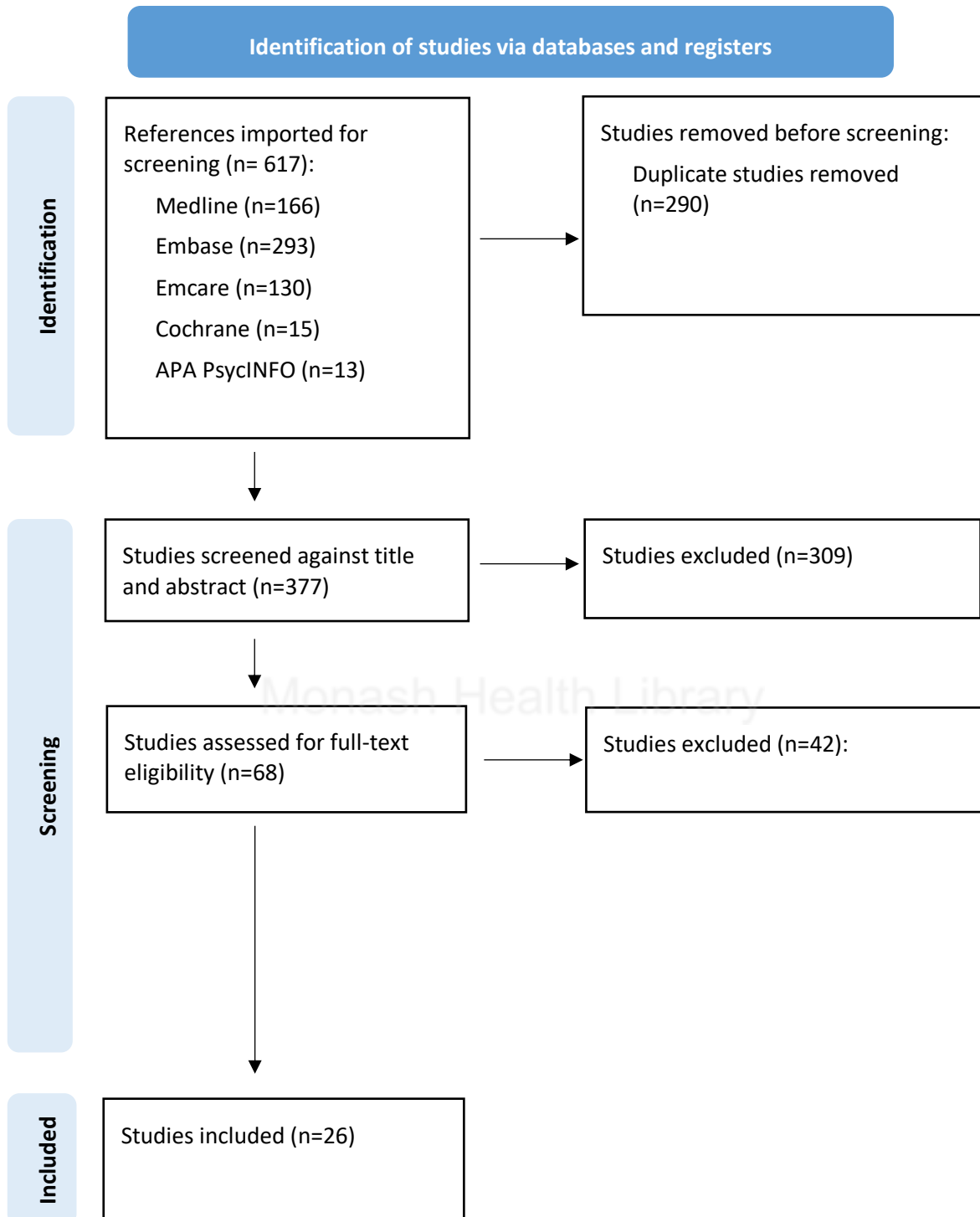| Concept | MeSH headings | Keywords |
|---|---|---|
| Medical emergency teams / systems / calls | Hospital Rapid Response Team/ | medical emergency + call(s) or team(s) or system(s). Rapid response + call(s) or team(s) or system(s). MET or RRT or RRS or CCOT + call(s) or team(s) or system(s). Code team(s). Critical care outreach. |
| Modified calling criteria | Early Warning Score/ | Calling criteria(ion). Activation criteria(ion). Afferent limb(s). Criteria, criterion. Parameter(s). Trigger(s/ing). Threshold(s). Score(s). Early Warning Score(s). EWS. MEWS. Track-and-trigger system(s). Modify(ied/ication/s) or change(s/d/ing) or alter(ed/ing/ation/s) or adjust(ed/ment/s) or amend(ed/ing/ment/s) or adapt(ed/ing/ation/s). |

## MEDLINE SEARCH STRATEGY

Ovid MEDLINE(R) ALL <1946 to June 11, 2024>

1 Hospital Rapid Response Team/ 1058
2 (medical emergency adj (call* or team* or system*)).mp. 861
3 (rapid response* adj (call* or team* or system*)).mp. 2153
4 ((MET or RRT or RRS or CCOT) adj (call* or team* or system*)).mp. 467
5 (code team* or critical care outreach).tw,kf. 308
6 1 or 2 or 3 or 4 or 5 3068
7 Early Warning Score/ and (modif* or chang* or alter* or adjust* or amend* or adapt*).tw,kf. 182
8 (calling criteri* or activation criteri*).ti. 48
9 (afferent limb* adj5 (modif* or chang* or alter* or adjust* or amend* or adapt*)).mp. 21
10 ((modif* or chang* or alter* or adjust* or amend* or adapt*) adj5 criteri*).mp. 23078
11 ((calling criteri* or activation criteri*) and (modif* or chang* or alter* or adjust* or amend* or adapt*)).mp. 103
12 (((criteri* or threshold* or score*) adj5 (activat* or call*)) and (modif* or chang* or alter* or adjust* or amend* or adapt*)).tw,kf. 3918
13 ((early warning score* or EWS) and (modif* or chang* or alter* or adjust* or amend* or adapt*)).tw,kf. 1568
14 (track-and-trigger system* and (modif* or chang* or alter* or adjust* or amend* or adapt*)).mp. 35
15 MEWS.tw,kf. 477
16 7 or 8 or 9 or 10 or 11 or 12 or 13 or 14 or 15 28606
17 6 and 16 230
18 limit 17 to yr="2014 -Current" 161

*Note*: A multifaceted search was undertaken, including search strategy variations incorporating terms such as "parameters" and "triggers".

## PRISMA CHART

**Identification of studies via databases and registers**

**Identification**

References imported for screening (n= 617):

Medline (n=166)

Embase (n=293)

Emcare (n=130)

Cochrane (n=15)

APA PsycINFO (n=13)

Studies removed before screening:

Duplicate studies removed (n=290)

**Screening**

Studies screened against title and abstract (n=377)

Studies excluded (n=309)

Studies assessed for full-text eligibility (n=68)

Studies excluded (n=42):

**Included**

Studies included (n=26)