

Research Article

Evaluation of an Early Warning System in Adult Ward Patients: A Single-Center Retrospective Observational Study

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Abstract

Objectives: This study aimed to evaluate the clinical performance of the Early Warning System (EWS) in adult patients undergoing rapid response team (RRT) activation and to assess its association with intensive care unit (ICU) transfer, in-hospital mortality, and code blue events.

Methods: This retrospective observational study included adult patients who underwent RRT activation between 2020 and 2022. Demographic characteristics, EWS scores, response times, and clinical outcomes were analyzed. Univariate analyses, ROC curve analysis, and logistic regression were used to evaluate the predictive performance of EWS.

Results: A total of 242 patients were included. The mean age was 57.4 ± 17.0 years, and the mean EWS was 6.1 ± 2.1 . Following RRT assessment, 75.6% of patients continued ward-based follow-up, while 10.7% required ICU transfer. Blue code activation occurred in 1.7% of cases. Comparison of three-year periods before and after EWS implementation showed a 31.7% reduction in code blue events. EWS was not significantly associated with adverse outcomes, and ROC analysis demonstrated limited discriminative ability ($AUC=0.525$).

Conclusion: EWS facilitates early recognition and timely escalation of care but demonstrates limited standalone prognostic performance, supporting its role as a decision-support tool alongside clinical judgment.

Keywords: Early Warning System, Clinical Monitoring, Code Blue Event, ICU, Patient Safety

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Early warning systems (EWS) are structured tools designed to detect early signs of clinical deterioration in hospitalized patients and play a crucial role in improving patient safety and clinical outcomes.^[1] Widely known systems like MEWS, NEWS, and NEWS2 use core physiological parameters such as respiratory rate, oxygen saturation, systolic blood pressure, heart rate, body temperature, and level of consciousness to generate a cumulative score indicating the severity of a patient's condition.^[2] Evidence has shown that using EWS contributes to reducing unplanned

intensive care unit (ICU) admissions, cardiac arrests, and hospital mortality by ensuring timely interventions.^[3]

NEWS 2, endorsed by the National Institute for Health and Care Excellence (NICE), has become a national standard in the UK due to its consistent structure and widespread applicability.^[4,5] However, it has been noted that the implementation of EWS carries risks such as over-reliance on the scoring system and neglect of clinical experience, and therefore it has been argued that the use of the Individual Early Warning Score (I-EWS), which integrates clinical judgement with scor-

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ing, may enable earlier detection of patient deterioration.^[6] Furthermore, it has been reported that the NEWS scores of patients presenting to the emergency department are correlated with hospital admission, length of hospital stay, and 30-day mortality.^[7] Reported limitations of these systems include variability in EWS performance across clinical settings, inconsistent staff adherence, and delays in response time.^[8]

In our country, data on the implementation and effectiveness of EWS in clinical practice remain limited. An adult EWS protocol based on international standards, including a structured monitoring and escalation pathway, was implemented in our hospital in 2019, and the present study retrospectively analyzed EWS activations between 2020 and 2022. The protocol includes automatic scoring through the hospital's electronic health record system and stratified interventions based on defined thresholds. The aim of this study is to evaluate the effectiveness of the EWS in identifying clinical deterioration and its association with ICU transfers, code blue events, and mortality.

Methods

This retrospective observational study was approved by the Istanbul Medipol University Clinical Research Ethics Committee on 06 July 2022 (Ethics Committee No: E-10840098-772.02-3986; Decision No: 600). EWS records implemented in our hospital between January 1, 2020 and December 31, 2022 were retrospectively reviewed. Informed consent was waived owing to the retrospective study design.

Adult hospitalized patients aged ≥ 16 years who underwent EWS assessment and subsequent rapid response team (RRT) activation were included in the study. Patients under sedation, those in the perioperative period, and cases with incomplete documentation were excluded. A total of 250 EWS activations were screened; after exclusion of 8 records due to missing data, 242 patients were included in the final analysis.

The EWS score is calculated based on core physiological parameters that are most commonly used in clinical practice, including respiratory rate, oxygen saturation, body temperature, systolic arterial blood pressure, heart rate, level of consciousness, and oxygen supplementation.^[9] All parameters were measured by nursing staff in accordance with the institutional "Vital Signs Collection Protocol" and documented in the electronic health record system under the "Vital Signs" module. The EWS was automatically calculated by the system, which also generated recommendations regarding monitoring frequency and escalation of care.

According to the institutional EWS protocol, patients with a score of 0 were monitored at 4-hour intervals, whereas those with scores of 1–4 underwent hourly monitoring. Patients with scores of 5–6 or a score of 3 in any single parameter were monitored every 30 minutes, and the responsible physician and the RRT were notified. Patients with scores ≥ 7 or with any parameter categorized in the red column of the EWS chart (critically abnormal range) required continuous monitoring at 5-minute intervals and immediate clinical escalation (Fig. 1). For each EWS activation, an "Early Warning Intervention Record Form" was completed and archived by the hospital's quality department.

Demographic characteristics, EWS scores, response times, clinical interventions, code blue activations, ICU transfers, and in-hospital mortality were retrospectively extracted from these records. A composite outcome was defined as ICU transfer, in-hospital death, order revision, or transfer to another department following RRT assessment.

Statistical Analysis

Statistical analyses were performed using SPSS software version 26.0 (IBM Corp., Armonk, NY, USA). Continuous variables were expressed as mean \pm standard deviation or median (interquartile range), depending on data distribution, while categorical variables were presented as frequency

Parameters		3	2	1	0	1	2	3	
Respiratory rate (breaths/min)	≤ 5	6–8	–	9–11	12–20	–	21–24	25–34	> 35
Oxygen saturation (%)	≤ 80	81–90	91–93	94–95	≥ 96	–	–	–	–
Supplemental oxygen	–	–	Yes	–	No	–	–	–	–
Body temperature ($^{\circ}\text{C}$)	–	≤ 35	–	35.1–36.0	36.1–38.0	38.1–39.0	> 39.1	–	–
Systolic BP (mmHg)	≤ 69	70–90	91–100	101–110	111–219	–	–	≥ 220	–
Heart rate (beats/min)	≤ 39	40–49	–	–	50–90	91–110	111–130	131–140	> 140
Level of consciousness	Unresponsive	–	–	–	Alert	–	–	Responds to voice/pain	–

Figure 1. Institutional early warning system (EWS) scoring chart with color-coded risk stratification.

and percentage. Comparisons between groups were conducted using Pearson's chi-square test or Fisher's exact test for categorical variables and the independent samples t-test or Mann–Whitney U test for continuous variables, as appropriate. Temporal trends were assessed using one-way analysis of variance (ANOVA) or the Kruskal–Wallis test.

Receiver operating characteristic (ROC) curve analysis was performed to evaluate the discriminative ability of EWS for predicting the composite outcome. Univariable logistic regression analysis was used to assess associations between EWS and clinical outcomes. A two-sided p-value <0.05 was considered statistically significant.

Results

A total of 242 patients who underwent RRT activation during the study period were included in the analysis. The mean age of the study population was 57.4 ± 17.0 years. Of these patients, 57.0% were male, and the majority of RRT calls originated from medical wards (77.3%), while 22.7% were from surgical wards. Most activations occurred in 2021 (50.0%), followed by 2022 (34.3%) and 2020 (15.7%). The most common reason for RRT activation was cancer-related clinical deterioration (47.1%), followed by infection-related causes (16.5%), cardiac or respiratory deterioration (14.0%), surgical complications (9.1%), and other causes (13.2%). Following RRT assessment, active clinical follow-up was the most frequent outcome (75.6%), whereas 10.7% of patients required transfer to the ICU. Blue code activation occurred in 1.7% of patients, and in-hospital mortality was observed in 0.4% (Table 1). In addition, a descriptive comparison of institutional data revealed a reduction in the number of code blue activations following EWS implementation. When comparing the three-year periods before and after EWS implementation, the total number of code blue events decreased from 687 to 469 cases, representing a 31.7% reduction.

The median arrival time of the RRT was 5 minutes (interquartile range [IQR], 8 minutes). The mean EWS Score was 6.1 ± 2.1 , and the distribution of EWS scores approximated a normal pattern, as illustrated in Figure 2.

When patients were stratified according to EWS score risk groups, 205 patients (84.7%) were classified as high risk (EWS ≥ 5), while 37 patients (15.3%) were categorized as low risk (EWS <5). Patients in the high-risk group were significantly more likely to be male compared with the low-risk group (60.0% vs. 40.5%, $p=0.028$). No statistically significant differences were observed between low- and high-risk groups with respect to clinic type, reason for RRT activation, overall clinical outcome or blue code activation (Table 2).

ROC curve analysis was performed to evaluate the discriminative ability of EWS for predicting the composite outcome

Table 1. Categorical baseline characteristics of patients undergoing rapid response team activation

Variable	n=242 (%)
Sex	
Male	138 (57.0)
Female	104 (43.0)
Year of admission	
2020	38 (15.7)
2021	121 (50.0)
2022	83 (34.3)
Clinic	
Non-surgical patients	187 (77.3)
Surgical patients	55 (22.7)
Reason for RRT activation	
Infection	40 (16.5)
Cardiac / Respiratory	34 (14.0)
Cancer-related deterioration	114 (47.1)
Surgical complication	22 (9.1)
Other	32 (13.2)
EWS Score Risk Group	
Low risk (EWS <5)	37 (15.3)
High risk (EWS ≥ 5)	205 (84.7)
Clinical outcome after RRT assessment	
Active clinical follow-up	183 (75.6)
ICU transfer	26 (10.7)
Order revision	29 (12.0)
Transfer to another department	3 (1.2)
Exitus	1 (0.4)
Blue code activation	
Yes	4 (1.7)
No	238 (98.3)

Data are presented as n (%). RRT: Rapid response team; EWS: Early Warning System; ICU: intensive care unit. EWS Risk Group (Low <5 / High ≥ 5)

(Fig. 3). The AUC for EWS score was 0.525, indicating limited discriminative performance in identifying patients who experienced the composite outcome. Consistent with this finding, univariable logistic regression analysis demonstrated that EWS was not significantly associated with composite outcome (odds ratio [OR] 1.01, 95% confidence interval [CI] 0.88–1.16; $p=0.896$), with negligible explained variance (Nagelkerke $R^2=0.000$).

Further univariate analyses revealed that blue code activation was significantly more frequent among patients who experienced composite outcomes (including ICU transfer,

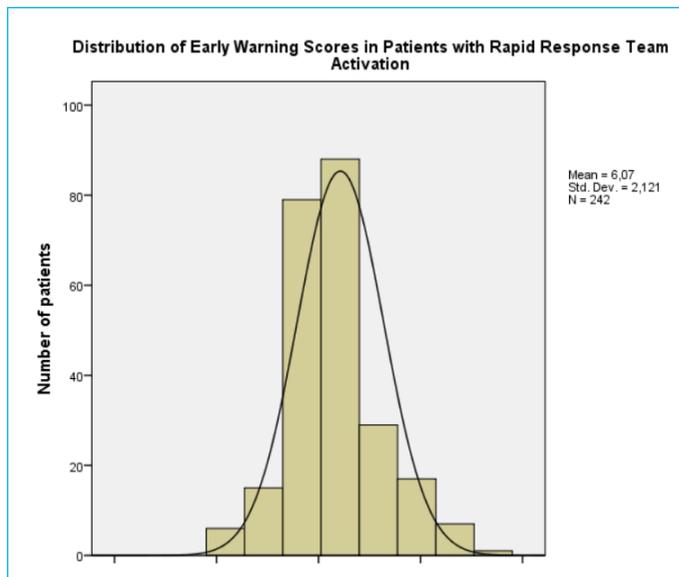


Figure 2. Distribution of early warning system (EWS) scores among patients undergoing rapid response team activation. The solid line represents the normal distribution curve.

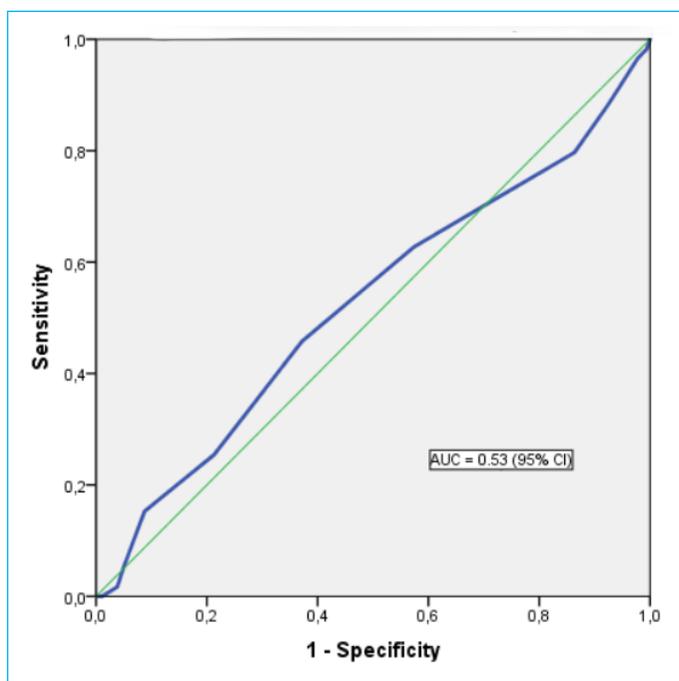


Figure 3. ROC curve of the early warning system scores for predicting the composite outcome.

in-hospital death, order revision, or transfer to another department) compared with those managed with active clinical follow-up (6.8% vs. 0.0%, $p=0.003$) (Table 3).

Discussion

In this retrospective observational study, we evaluated the clinical performance of the EWS in adult patients undergo-

Table 2. Comparison of categorical variables according to EWS score risk groups

Variable	Low risk (EWS<5) n=37	High risk (EWS≥5) n=205	p
Sex			0.028
Male	15 (40.5)	123 (60.0)	
Female	22 (59.5)	82 (40.0)	
Clinic			0.126
Non-surgical patients	25 (67.6)	162 (79.0)	
Surgical patients	12 (32.4)	43 (21.0)	
Reason for RRT activation			0.499
Infection	4 (10.8)	36 (17.6)	
Cardiac / Respiratory	3 (8.1)	31 (15.1)	
Cancer-related deterioration	19 (51.4)	95 (46.3)	
Surgical complication	5 (13.5)	17 (8.3)	
Other	6 (16.2)	26 (12.7)	
Clinical outcome after RRT assessment			0.531
Active follow-up	25 (67.6)	158 (77.1)	
ICU transfer	5 (13.5)	21 (10.2)	
Order revision	7 (18.9)	22 (10.7)	
Transfer to another department	0 (0.0)	3 (1.5)	
Exitus	0 (0.0)	1 (0.5)	
Blue code activation			0.487†
No	36 (97.3)	202 (98.5)	
Yes	1 (2.7)	3 (1.5)	

Data are presented as n (%). Comparisons were performed using the chi-square test or Fisher's exact test, as appropriate. RRT: Rapid response team; EWS: Early Warning System; ICU: intensive care unit. †Fisher's exact test was used due to small cell counts.

ing RRT activation and examined its association with clinical outcomes, including ICU transfer, in-hospital mortality, and code blue events. Our findings demonstrate that the EWS supported timely clinical assessment and intervention by facilitating the identification of patients requiring urgent care; however, its standalone prognostic performance was limited in this cohort.

The majority of patients included in the study were managed in medical wards, and cancer-related clinical deterioration was the most frequent trigger for RRT activation. This reflects the high burden of complex and vulnerable patient populations in tertiary care settings and underscores the importance of continuous monitoring systems capable of detecting early physiological instability. In our cohort,

Table 3. Univariate comparison of categorical variables between patients managed with active clinical follow-up and those with composite outcomes following RRT assesment

Variable	Active clinical follow-up (n=183)	Composite outcomes (n=59)	p
Sex			0.424
Male	107 (58.5%)	31 (52.5%)	
Female	76 (41.5%)	28 (47.5%)	
Clinic			0.355
Non-surgical patients	144 (78.7%)	43 (72.9%)	
Surgical patients	39 (21.3%)	16 (27.1%)	
Reason for RRT activation			0.498
Infection	33 (18.0%)	7 (11.9%)	
Cardiac / respiratory	24 (13.1%)	10 (16.9%)	
Cancer-related deterioration	83 (45.4%)	31 (52.5%)	
Surgical complication	19 (10.4%)	3 (5.1%)	
Other	24 (13.1%)	8 (13.6%)	
Blue code activation			0.003
No	183 (100.0%)	55 (93.2%)	
Yes	0 (0.0%)	4 (6.8%)	
EWS risk group			0.215
Low risk (EWS score <5)	25 (13.7%)	12 (20.3%)	
High risk (EWS score ≥5)	158 (86.3%)	47 (79.7%)	

Data are presented as n (%). p values were calculated using Pearson's chi-square test or Fisher's exact test, as appropriate. Composite outcomes were defined as ICU transfer, in-hospital death, order revision, or transfer to another department. RRT: Rapid response team; EWS: Early warning system; ICU: Intensive care unit.

more than three-quarters of patients were stabilized following RRT assessment and continued to be managed on the ward, while only a minority required ICU transfer or experienced mortality. Consistent with the literature, these findings suggest that early recognition and timely intervention may have contributed to preventing further clinical deterioration.^[10,11]

Stratification according to EWS risk groups suggested that high-risk patients (EWS ≥5) may exhibit more pronounced physiological derangements, including higher heart rates, lower oxygen saturation levels, and increased oxygen requirements. These parameters are well-recognized indicators of acute physiological stress and clinical instability

and support the construct validity of the EWS as a tool for identifying patients at increased risk of deterioration.^[12] Additionally, high-risk patients tended to require a greater number of clinical interventions, which may reflect increased clinical complexity and care demands.^[13]

In line with literature, the current study show that EWS was not significantly associated with the composite outcome in univariable logistic regression analysis.^[14,15] Similarly, ROC curve analysis demonstrated a limited discriminative ability, with an AUC of 0.525. These findings may appear to challenge the effectiveness of EWS. However, this apparent limitation should be interpreted in the context of the intended purpose of EWS. The system was designed primarily as an early detection and escalation tool to prompt timely clinical evaluation and intervention, rather than as a definitive prognostic model for predicting downstream outcomes. The lack of a significant correlation between EWS scores and adverse clinical outcomes may be interpreted as a consequence of timely clinical interventions following EWS activation, leading to early stabilization of patients and prevention of further deterioration.^[16]

In settings where early recognition leads to prompt intervention, the progression to severe outcomes such as ICU transfer or death may be mitigated. This paradoxically reduces outcome variability and weakens the apparent predictive performance of the score for these endpoints. Therefore, the low AUC observed in our study likely reflects the effectiveness of early intervention rather than the inadequacy of the EWS system itself. Similar observations have been reported in previous studies, which emphasize that early warning scores are most effective when used as part of a broader clinical decision-making framework rather than as isolated predictors.^[8]

Importantly, blue code activation was rare in our cohort and occurred more frequently among patients who experienced composite outcomes, underscoring its clinical relevance as a marker of severe deterioration and supporting its use as a meaningful outcome measure. The observed 31.7% reduction in code blue events when comparing the three-year periods before and after EWS implementation may reflect the institutional impact of structured early warning and escalation processes, enabling earlier recognition of clinical deterioration and timely multidisciplinary interventions before progression to cardiopulmonary arrest. The overall low incidence of blue code activations further suggests that structured monitoring and prompt RRT involvement may contribute to the prevention of catastrophic clinical events.^[17]

The lack of significant association between delayed RRT arrival time and adverse outcomes is another noteworthy

finding. Although delayed responses were observed in a subset of cases, these delays were not associated with increased rates of ICU transfer or in-hospital mortality. This may be attributable to compensatory mechanisms, including early bedside nursing interventions, continuous monitoring, and escalation initiated before formal RRT arrival.^[18]

The distribution of EWS scores in our study population demonstrated that most RRT activations occurred at moderate-to-high score levels, consistent with the system's role in identifying patients requiring urgent evaluation. However, the absence of a strong relationship between EWS risk category and clinical outcomes further supports the notion that EWS functions best as a trigger for assessment rather than a prognostic endpoint. This observation aligns with growing evidence suggesting that EWS should be complemented by clinical assessment, dynamic trend analysis, and contextual patient factors.^[19]

Although advanced models such as EventScore have been developed to provide adaptable and data-driven early warning systems, our findings highlight that even standardized, rule-based EWS protocols can yield substantial benefits in daily clinical practice.^[20] Moreover, the future integration of artificial intelligence into these systems holds great promise for further enhancing predictive accuracy, reducing false alarms, and improving clinical decision-making.^[21,22] While our results confirm the clinical utility of a structured EWS protocol, particularly in reducing code blue events and guiding ICU transfers, artificial intelligence-driven approaches may represent the next crucial step toward achieving more personalized and proactive patient safety strategies.^[20]

Several limitations of this study should be acknowledged. The retrospective design limits causal inference, and the single-center setting may restrict generalizability. Additionally, the low incidence of mortality and ICU transfer, while clinically favorable, may have reduced the statistical power to detect associations between EWS and adverse outcomes. Multivariable models incorporating comorbidities, laboratory parameters, and dynamic changes in vital signs were not evaluated and may offer improved prognostic performance in future studies.

Conclusion

In conclusion, our findings support the role of the EWS as a clinically valuable tool for early recognition and escalation of care rather than as a standalone prognostic model. Although ROC and regression analyses demonstrated limited discriminative performance for predicting ICU transfer or in-hospital mortality, this may reflect the effectiveness of timely interventions triggered by EWS activation, leading to patient stabilization before progression to severe outcomes. These results highlight the importance of inte-

grating EWS with clinical judgment, physiological trends, and contextual patient information. Future prospective and multicenter studies incorporating multivariable and dynamic modeling approaches are warranted to further refine risk stratification and enhance patient safety.

Disclosures

Ethics Committee Approval: This retrospective observational study was approved by the Clinical Research Ethics Committee of Istanbul Medipol University on 06 July 2022 (Ethics Committee No: E-10840098-772.02-3986; Decision No: 600). The research was carried out in compliance with institutional ethical standards and with the principles of the 1964 Declaration of Helsinki, including its subsequent amendments and equivalent guidelines.

Informed Consent: Informed consent was waived owing to the retrospective study design.

Conflict of Interest: The authors declare that they have no conflict of interests.

Use of AI for Writing Assistance: The authors declare that no artificial intelligence–assisted technologies were used in the preparation of this manuscript.

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