SAJEM EMERGENCY MEDICINE JOURNAL

ORIGINAL ARTICLE

A comparison of the accuracy of modified early warning score, national early warning score, and rapid emergency medicine score in predicting length of hospital stay and in-hospital mortality in adults presenting to the emergency department

Salman Naeem[1], Tamoor Gill[2], Rahma Fiaz[3], Almas Ashraf[4], Muneeba Nasir[5]

Authors Affiliation:

Barts Health NHS trust, UK,[1]

Bahria International Hospital Orchard, Lahore Pakistan,[2]

Evercare Hospital, Lahore, Pakistan,[3]

Shifa College of Medicine, Islamabad, Pakistan,[4]

Leicester Hospital, Stevenage, UK,[5]

Correspondence to:

Salman Naeem
slmn_nm@yahoo.com

ABSTRACT

OBJECTIVE

The National Early Warning Score (NEWS) is a system used in many hospitals in the United Kingdom. This study compares the accuracy of NEWS, the Modified Early Warning Score (MEWS) and the Rapid Emergency Medicine Score (REMS) in predicting in-hospital length of stay (LOS) mortality in patients presenting to the emergency department (ED).

METHODS

A prospective, observational cohort study was conducted in a tertiary care hospital in Pakistan from October, 2014 to December, 2014. All patients ≥16 years were consecutively sampled over three months, presenting to the ED who met the inclusion criteria. Observations were recorded at triage. NEWS, MEWS and REMS were categorized into low, medium and high for regression analysis and compared using receiver operating curve (ROC) analysis. A multivariable logistic regression (MLR) model was used to identify factors associated with LOS and in-hospital mortality.

RESULTS

In total, 4032 patients were recruited (mean age, 47 ± 17 years); 52% were male. In-hospital mortality was 5%, mean ED and hospital LOS were 0.15 ± 0.36 days and 1.86 ± 4.26 days, respectively. ROC for in-hospital mortality and LOS for NEWS, REMS, and MEWS were 0.79, 0.72, 0.64 and 0.61, 0.59, and 0.53, respectively. Mortality and LOS increased with increasing early warning scores. Medium and high NEWS had a strong association with mortality and LOS, respectively. Age, LOS, medium, and high NEWS were associated with mortality on MLR.

CONCLUSION

NEWS was a superior scale in predicting LOS and in-hospital mortality in patients presenting to ED as compared to REMS and MEWS.

KEYWORDS

NEWS, REMS, MEWS, Pakistan, Emergency Department

Introduction

The emergency department (ED) serves as the front for receiving acutely sick patients. An accurate assessment of severity is essential because timely interventions improve survival outcomes in both medical and surgical patients. [1–3] Until now, many early warning scores (EWS) have been devised over the years to identify patients who are at risk of deterioration. [4,5]

The National EWS (NEWS), Modified EWS (MEWS), and the Rapid Emergency Medicine Score (REMS) are the most commonly used scores for ED patients. These systems are composed of physiological parameters that can be measured quickly, thereby ensuring rapid assessment of an acutely ill patient who requires urgent intervention. [6] MEWS has helped predict the mortality of patients in prehospital settings and ED. REMS was based on the acute physiology and chronic health evaluation scoring system (APACHE-II), a reliable scoring system for predicting adverse outcomes in patients. [7,8] The latest of these is NEWS, an aggregated weighted scoring system including the estimation of six vital signs and the amount of oxygen inspired by the patient at a given time. [9,10]

As of 2014, only four published studies have addressed the correlation between the implementation of EWS and its effect on mortality. [11-14] Maupin et al. [15] and Green and Williams [16] demonstrated a decline in the number of "code blue" calls following the implementation of EWS; however, the statistical significance of the reduction was not determined. Those studies imply a decrease in mortality with the use of EWS, yet only one study established reduced

mortality on statistically significant grounds. Up till now, three studies in the literature have investigated the influence of implementing EWS on the duration of LOS for patients and concluded mixed outcomes due, in part, to the differences in study populations and the difference in study designs. [11,16,17] Bulut et al. concluded that REMS is superior to MEWS predicting adverse outcomes in hospitalized patients; however, NEWS was not considered. [18]

This study aims to compare the accuracy of NEWS, REMS, and MEWS in predicting the hospital LOS and in-hospital mortality for patients admitted through the ED.

METHODS

A prospective, single-center, observational cohort study was conducted in Shifa International Hospital, Pakistan's urban tertiary care teaching hospital, with 40,000 annual ED presentations. Patients were consecutively sampled from October 2014 to December 2014. The study included medical and surgical adult patients aged 16 to 80 years presenting to the ED. Pregnant women, patients who had cardio-pulmonary resuscitation out of the hospital, those transported to the ED in cardiac arrest, those left against medical advice, those with incomplete data, and all other emergency referrals to and from other hospitals were excluded. The institutional review board and ethics committee approved the research study design.

Observations were recorded at triage. The study's endpoint was the length of stay and patient death during that admission. NEWS, MEWS, and REMS were then calculated from the original observations and categorized in low-risk (NEWS ≤ 4; MEWS ≤ 4; REMS ≤ 5), medium-risk (NEWS 5 to 6; MEWS 5 to 6; REMS 6 to 13), and high-risk (NEWS ≥ 7; MEWS ≥ 7; REMS ≥ 14) categories.

Statistical analysis was carried out using IBM SPSS Statistics for Windows, Version 20.0. (IBM Corp., Armonk, NY, USA). We used the Shapiro–Wilk test to evaluate the normality of continuous variables. Continuous variables were stated as mean ± standard deviation (SD), and categorical variables were computed as frequencies and percentages. Categorical variables were compared using the chi-square test or Fisher's exact test (when necessary). The continuous variables were compared using the independent t-test. Receiver operating characteristics (ROC) curve analysis was performed to evaluate and compare the performances of the three scores. A multivariable logistic regression model was used to identify the independent risk factors associated with mortality and hospital stay. Statistical significance was defined as a two-tailed p-value of 0.05.

RESULTS

Table I presents the baseline description of 4032 patients with a mean age and SD of 47 ± 17 years. Just over half of the study population (52%) were male. Also, 94% of respondents were in the low MEWS category, and 86% were in the low NEWS category. Additionally, 80% of the patients were in the low REMS category. The patients' mean ED and hospital stay were 0.15 ± 0.36 days and 1.86 ± 4.26 days, respectively.

Sixty-eight patients (1.7%) had high MEWS, of which 24 (35.3%) died. Three hundred and six patients (7.6%) had high NEWS, and of those, 98 (32.0%) died. Eighty-two patients (2.0%) had high REMS, and of those, 33 patients (40.2%) died. We noted a significant (P=0.001) association between the clinical severity of disease and mortality (Table I). NEWS and MEWS were also significantly (p = 0.001) associated with mortality (Table I).

Our multivariable analysis revealed three independent variables as significant risk factors for death: age (adjusted odds ratio [AOR], 1.03; 95% confidence interval [CI], 1.02 to 1.04; p = 0.001), medium NEWS (AOR, 7.61; 95% CI, 4.89 to 11.85; p = 0.001), high NEWS (AOR, 12.74; 95% CI, 7.97 to 20.36; p = 0.001), and hospital LOS (AOR, 1.04; 95% CI, 1.01 to 1.07; p = 0.004) as shown in Table I. NEWS had an area under the curve (AUC) of 0.79 compared REMS AUC of 0.72 and MEWS AUC of 0.64 (Figure 1).

We also identified three factors significantly related to hospital LOS: age (AOR, 1.02; 95% CI, 1.02 to 1.02; p = 0.001), medium NEWS (AOR, 3.26; 95% CI, 2.45 to 4.33; p = 0.001), high NEWS (AOR, 5.86; 95% CI, 4.19 to 8.17; p = 0.001), and ED LOS (AOR, 1.48; 95% CI, 1.20 to 1.81 p = 0.001) as shown in Table II. NEWS AUC was 0.61; REMS AUC was 0.59, and MEWS AUC was 0.53 (Figure 2).

DISCUSSION

Based on our results, NEWS performed better than MEWS and REMS in predicting LOS and in-hospital mortality for patients presenting to the ED. MEWS was the worst-performing score, while REMS was similar to NEWS in predicting adverse outcomes. The area under the ROC (AUROC) value for NEWS was better than that of MEWS and REMS for hospital LOS and in-hospital mortality. To the best of our knowledge, this is the first study to compare MEWS, NEWS, and REMS to predict in-hospital mortality and LOS in a single-patient cohort.

Various studies have identified predictors of patient outcomes before. In a study comparing MEWS with REMS conducted by Bulut et al., [18] MEWS was inferior to REMS in predicting in-hospital mortality (AUROC

Variables	Total frequency, N (%)	Alive (n = 3830; 95.0%)	Death (n = 202; 5.0%)	p-value	Adjusted OR (CI), p-value
Age in years (Mean ± SD)	47.12 ± 17.71	46.50 ± 17.70	58.87 ± 13.09	0.001	1.03 (1.02 1.04), 0.001
Sex					
Female	1930 (47.9%)	1839 (95.3%)	91 (4.7%)	0.411	**Reference**
Male	2102 (52.1%)	1991 (94.7%)	111 (5.3%)		1.25 (0.91 1.72), 0.18
MEWS*					
Low	3772 (93.6%)	3637 (96.4%)	135 (3.6%)	0.001	**Reference**
Medium	192 (4.8%)	149 (77.6%)	43 (22.4%)		1.62 (1.01 2.58), 0.04
High	68 (1.7%)	44 (64.7%)	24 (35.3%)		1.63 (0.83 3.14), 0.16
NEWS**					
Low	3469 (86.0%)	3406 (98.2%)	63 (1.8%)	0.001	**Reference**
Medium	257 (6.4%)	216 (84.0%)	41 (16.0%)		7.61 (4.89 11.85), 0.001
High	306 (7.6%)	208 (68.0%)	98 (32.0%)		12.74 (7.97 20.36), 0.001
REMS***					
Low	3220 (79.9%)	3140 (97.5%)	80 (2.5%)	0.001	**Reference**
Medium	730 (18.1%)	641 (87.8%)	89 (12.2%)		1.15 (0.75 1.76), 0.53
High	82 (2.0%)	49 (59.8%)	33 (40.2%)		1.28 (0.63 2.59), 0.49
ED Stay in Days (Mean ± SD)	0.15 ± 0.36	0.15 ± 0.36	0.20 ± 0.42	0.04	1.12 (0.75 1.67), 0.57
Hospital LOS in Days (Mean ± SD)	1.86 ± 4.26	1.70 ± 4.12	4.77 ± 5.74	0.001	1.04 (1.01 1.07), 0.004

Table 1: Baseline characteristics of mortality and adjusted odds ratio.

Footnote: * Modified early warning score, ** National early warning score, ***Rapid emergency medicine score, (CI) Confidence Interval, (SD) Standard deviation.

for MEWS 0.630; AUROC for REMS 0.707). These results were consistent with our study. REMS (AUROC, 0.72) performed better than MEWS (AUROC, 0.64). However, NEWS (AUROC, 0.79) had an overall better prediction for in-hospital mortality in this study.

A study conducted by Olsson et al. compared REMS with the APACHE-II score in the ED population. REMS performed comparable to APACHE-II (AUROC, 0.911 ± 0.015; AUC, 0.901 ± 0.15; p = 0.218).[8] Bulut et al. compared REMS and MEWS in surgical and medical patients presenting to the ED. [18] They classified patients as low-risk (REMS ≤ 5), intermediate-risk (REMS 6 to 13), and high-risk (REMS > 13) and found that the risk of death increased from 2.923 in intermediate-risk to 14.564 in high-risk patients when compared with low-risk patients. Our study was consistent with Bulut et al.'s results. We noted an increasing trend in the in-hospital mortality with risk stratification from 2.5% in low-risk patients to 12% in medium-risk and 40% in high-risk patients. However, intermediate and high categories of REMS were not significantly associated with mortality on multivariate analysis.

MEWS has been used in various ICUs, EDs, wards, and prehospital settings in surgical and nonsurgical patients. Originally, MEWS consisted of six parameters (i.e., level of consciousness, heart rate, systolic blood pressure,

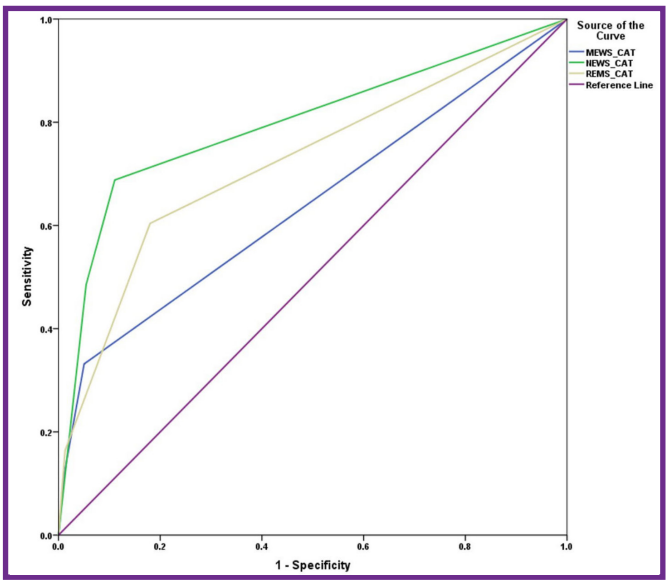

Figure 1: Receiver operating curve for NEWS, MEWS and REMS for predicting in-hospital mortality.

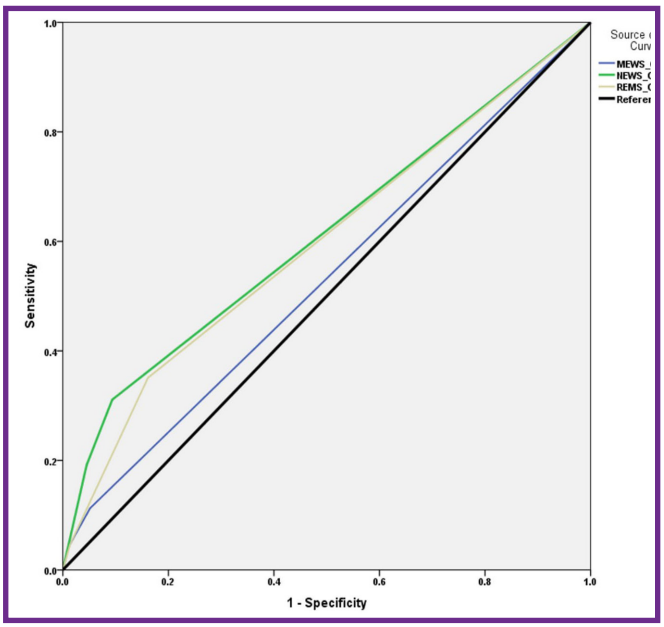

Figure II: Receiver operating curve for NEWS, MEWS and REMS for predicting length of stay in hospital.

temperature, respiratory rate, and urine output). However, it was modified to include only five parameters by excluding the urine output measurement for ease of use in an emergency setting. Studies found that MEWS of > 5 was associated with increased mortality, critical care admissions, and hospital LOS.[7] Bulut et al. found that MEWS ≥ 5 was significantly associated with mortality.[18] In our study, medium-risk MEWS of 5 to 6 were significantly associated with in-hospital mortality (OR, 1.62; CI, 1.01 to 2.58; p = 0.04) and hospital LOS (OR, 0.65; CI, 0.44 to 0.95; p = 0.03) while the AUROC of MEWS for predicting in-hospital mortality and hospital LOS was 0.64 and 0.53, respectively, similar to previous studies.

Numerous studies in the literature have evaluated NEWS for predicting in-hospital mortality and hospital or ICU admission. NEWS is being used in the UK to trigger an assessment of sepsis in patients, and it is superior to other emergency medicine scores in predicting mortality in septic patients. In a retrospective study by Chen et al. comparing NEWS, APACHE-II, and REMS in severely ill patients in EDs, they found that NEWS was superior to REMS but inferior to APACHE-II in predicting 28-day mortality. However, NEWS was more applicable to the ED population due to its ease of use.[19] Lee et al. found the AUROC for in-hospital mortality prediction was 0.765, and medium-risk and high-risk patients had significantly increased mortality risks. However, combining NEWS with age and diagnosis increased the accuracy of mortality prediction.[20] We obtained similar results in our study with AUROC of NEWS for mortality being 0.79 and significantly increased odds associated with medium-risk and high-risk categories (OR, 7.61; CI, 4.89 to 11.85; p = 0.001 and OR, 12.74; CI, 7.97 to 20.36; p = 0.001, respectively). Also, age and LOS in the hospital were significantly associated with in-hospital mortality.

Limited data support the use of NEWS, REMS, and MEWS for predicting hospital stay in patients presenting to the ED. After a literature search, there is no study comparing these three scores to predict hospital LOS. Medium-risk and high-risk patients were significantly associated with hospital LOS > 2 days (OR, 3.26; CI, 2.45 to 4.33; p = 0.001 and OR, 5.86; CI, 4.19 to 8.17; p = 0.001, respectively). Age, male sex, ED LOS, and medium-risk MEWS patients were also associated with hospital LOS > 2 days. NEWS had better accuracy in predicting hospital LOS > 2 days when compared with REMS and MEWS with AUROC of 0.61, 0.59, and 0.53, respectively.

This single-center study requires external validation. It was performed in a private tertiary care hospital, so there is selection bias as the majority of the population of Pakistan will not be able to access private healthcare. It indicates our study population is not truly representative of the wider Pakistani population in general. Many patients were transferred out of the hospital due to a lack of resources to continue medical treatment, so they were excluded from the study, which created a selection bias of the study population.

The data is seven years old. A newer modified version of NEWS is available, and further scores for patient monitoring have been produced. Hence this limits the

Variables	Total Frequency, N (%)	≤ 2 Days (n = 3180; 78.9%)	> 2 Days (n = 852; 21.1%)	p-value	Adjusted OR (CI), p-value
Age in years (Mean ± SD)	47.12 ± 17.71	45.36 ± 17.49	53.68 ± 16.95	0.001	1.02 (1.02 1.03), 0.001
Sex					
Female	1930 (47.9%)	1580 (81.9%)	350 (18.1%)	0.001	**Reference**
Male	2102 (52.1%)	1600 (76.1%)	502 (23.9%)		1.59 (1.35 1.87), 0.001
MEWS*					
Low	3772 (93.6%)	3016 (80.0%)	756 (20.0%)	0.001	**Reference**
Medium	192 (4.8%)	131 (68.2%)	61 (37.8%)		0.65 (0.44 0.95), 0.03
High	68 (1.7%)	33 (48.5%)	35 (51.5%)		0.94 (0.52 1.71), 0.85
NEWS**					
Low	3469 (86.0%)	2882 (83.1%)	587 (16.9%)	0.001	**Reference**
Medium	257 (6.4%)	155 (60.3%)	102 (39.7%)		3.26 (2.45 4.33), 0.001
High	306 (7.6%)	143 (46.7%)	163 (53.3%)		5.86 (4.19 8.17), 0.001
REMS***					
Low	3220 (79.9%)	2667 (82.8%)	553 (17.2%)	0.001	**Reference**
Medium	730 (18.1%)	470 (64.4%)	260 (35.6%)		1.06 (0.84 1.34), 0.62
High	82 (2.0%)	43 (52.4%)	39 (47.6%)		0.64 (0.36 1.13), 0.12
ED Stay in Days (Mean ± SD)	0.15 ± 0.36	0.13 ± 0.34	0.20 ± 0.41	0.001	1.48 (1.20 1.81), 0.001

TABLE II: Baseline characteristics of length of hospital stay and adjusted odds ratio

Footnote: * Modified early warning score, ** National early warning score, ***Rapid emergency medicine score, (CI) Confidence Interval, (SD) Standard deviation.

utility of the study. The statistical analysis was also limited due to lack of resources, and further analysis would have given more information.

CONCLUSION

EWS provides useful information to predict mortality and LOS for patients presenting to the ED. NEWS was found to be a superior scale in predicting in-hospital mortality and hospital LOS in medical and surgical patients compared to REMS and MEWS.

Disclaimer: This study was presented as a poster at the European society of emergency medicine 2018 conference in Glasgow, UK. Article no.15045 https://api.mycongressonline.net/api-Congress-agenda.html?key=ab10c6a3e4ba4db1629057c3d8dca3e66653b897&record=94925b06-e189-1a5d-15c9-599a8ab00779&tpl=agenda. All the authors of the study were present in Pakistan at the time the study was conducted.

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