JOURNAL OF
CONTEMPORARY MEDICINE

DOI:10.16899/jcm.1281069
J Contemp Med 2023;13(3):490-495

Original Article / Orijinal Araştırma

Use of Early Warning Scoring Systems to Predict the Prognosis of COVID-19 Patients in the Emergency Department

Acil Serviste COVID-19 Hastalarının Prognozunu Tahmin Etmek İçin Erken Uyarı Puanlama Sistemlerinin Kullanımı

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Abstract

Aim: Increased emergency department (ED) admissions and the need for intensive care unit (ICU) brought with the pandemic has led to the need to make fast and accurate decisions. Early warning scores (EWS) may be useful in ED in this regard. This study was performed to evaluate the effectiveness of EWS in predicting mortality and need for ICU of patients with COVID-19.

Material and Method: This retrospective observational study was performed with subjects presented to the ED and were later admitted to a general ward or to the ICU because of COVID-19. Subjects aged ≥18 years with positive RT-PCR were included in the study. Subjects experienced a cardiac or respiratory arrest or intubated at the time of presentation to the ED and pregnant women were excluded from the study. MEWS, NEWS, NEWS-2, REMS, and qSOFA scores were calculated using patients' data on first presentation. We examined the association of these scoring systems with mortality and need for ICU.

Results: While 60(10%) of the 600 patients participating in the study were admitted to the ICU, 222(37%) patients died. The scoring systems' negative predictive values for predicting ICU admission were 0.95, 0.98, 0.97, 0.96, and 0.96 respectively and for predicting mortality were 0.61, 0.67, 0.67, 0.66, and 0.61 respectively. All scorings assessed were significant predictors of the need for ICU and mortality in patients with COVID-19.

Conclusions: All evaluated scoring systems were successful; however, NEWS and NEWS-2 had the highest predictive value both for the need for ICU and mortality.

Keywords: Early warning score, Emergency medicine, COVID-19, prognosis, mortality

Öz

Amaç: Pandemi ile birlikte artan acil servis (AS) başvuruları ve yoğun bakım (YBÜ) ihtiyacı, hızlı ve doğru karar verme ihtiyacını doğurmuştur. Erken uyarı skorları (EUS) bu konuda acil serviste faydalı olabilir. Bu çalışma, EUS'nin COVID-19 hastalarının mortalitesini ve YBÜ ihtiyacını öngörmedeki etkinliğini değerlendirmek için yapıldı.

Gereç ve Yöntem: Bu retrospektif gözlemsel çalışma, acil servise sunulan ve daha sonra COVID-19 nedeniyle genel servise veya yoğun bakım ünitesine kabul edilen deneklerle gerçekleştirildi. Pozitif RT-PCR'si olan ≥18 yaşındaki denekler çalışmaya dahil edildi. Acil servise başvuru anında kalp veya solunum durması yaşayan veya entübe olan denekler ve hamile kadınlar çalışmadan çıkarıldı. MEWS, NEWS, NEWS-2, REMS ve qSOFA skorları hastaların ilk başvurudaki verileri kullanılarak hesaplandı. Bu skorlama sistemlerinin mortalite ve YBÜ ihtiyacı ile ilişkisini inceledik.

Bulgular: Çalışmaya katılan 600 hastanın 60'ı (10%) yoğun bakıma alınırken, 222 (37%) hasta öldü. Puanlama sistemlerinin YBÜ yatışını öngörmedeki negatif tahmin değerleri sırasıyla 0.95, 0.98, 0.97, 0.96 ve 0.96 ve mortaliteyi tahmin etmede sırasıyla 0.61, 0.67, 0.67, 0.66 ve 0.61 idi. Değerlendirilen tüm skorlar, COVID-19 hastalarında YBÜ ihtiyacı ve mortalitenin önemli belirleyicileriydi.

Sonuç: Değerlendirilen tüm puanlama sistemleri başarılıydı; ancak NEWS ve NEWS-2 hem YBÜ ihtiyacı hem de mortalite açısından en yüksek prediktif değere sahipti.

Anahtar Kelimeler: Erken uyarı skoru, Acil tıp, COVID-19, prognoz, mortalite

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Received *(Geliş Tarihi)*: 11.04.2023 **Accepted *(Kabul Tarihi)*:** 30.05.2023

INTRODUCTION

First identified in the city of Wuhan, China in December 2019, the novel coronavirus (SARS-CoV-2) has led to an outbreak of respiratory disease called coronavirus infectious disease 2019 (COVID-19), which has currently affected millions of people worldwide (1). COVID-19, with its several variants detected over time, typically presents with fever, myalgia, fatigue and dry cough, and some patients develop severe dyspnea and hypoxemia days after the onset of symptoms, resulting in more frequent presentation to emergency department (ED) and increased need for admission to general ward and intensive care unit (ICU) in hospitals (2). Previous studies have reported that the prevalence of hypoxemic respiratory failure is approximately 20% in hospitalized COVID-19 patients, and more than 25% of these patients require admission to ICU (3). In addition to simple laboratory parameters such as BUN/lymphocyte ratio (4), BUN/ albümin ratio (5), lactate clearance (6), various early warning scorings (EWS) (7) have been tried to predict the need for intensive care and mortality in COVID-19 patients.

EWS are physiological scoring systems based on prompt and quantitative evaluation of changes in vital symptoms (8). They have been initially developed to ensure early stabilization and transfer to the ICU when needed, to detect preventable cardiac arrests, to identify and monitor hospitalized patients at risk for deterioration outside critical care points (9,10). These scoring systems have also been investigated for their potential in identifying critically ill patients in the triage area (11), and the Rapid Emergency Medicine Score (REMS) has been specifically developed for this purpose (12). Although the National Early Warning Score (NEWS) (13) is the most common scoring system used in studies conducted with patients presenting to ED to predict both in-hospital mortality and ICU admissions (11). Furthermore, it is unclear which EWS is the most accurate for the triage of COVID-19 patients in the ED. Therefore, the primary objective of this study was to evaluate the potential utility of various EWS for triage in ED in Turkey which have been overstretched by COVID-19 cases.

MATERIAL AND METHOD

Study Design and Patient Selection

This is a retrospective, cross-sectional and observational study. After receiving approval from the local ethics committee with approval number of 0265 (27/05/2021), the study was conducted between 01/04/2020 and 01/04/2021 with patients who presented to the ED of a tertiary hospital with a preliminary diagnosis of COVID-19, who tested positive for PCR (regardless of variant) and who were admitted to the general ward or ICU at the same hospital. Patients aged <18 years at the time of presentation to the ED, patients who were intubated or had cardiac or respiratory arrest on presentation and pregnant patients were excluded from the study.

Data Collection

Data were collected retrospectively, by screening medical records of patients who presented to the ED of our hospital and were later admitted to a general ward and/or to the ICU with a preliminary diagnosis of PCR+COVID-19. Patients' data collected from screened files including respiratory rate, systolic blood pressure (SBP), diastolic blood pressure (DBP), mean arterial pressure (MAP), pulse rate, temperature, 02 saturation, state of consciousness (GCS/AVPU), admission status (general ward/ICU), mortality, age, and sex were recorded in prepared case report forms. EWS were calculated for each patient using the recorded data. For this purpose, we used MEWS, NEWS, NEWS 2, qSOFA, and REMS early warning scoring systems, which are known to be valid and quick tools in ED settings. MEWS is a scoring scale consisting of systolic blood pressure, heart rate, respiratory rate, body temperature, and state of consciousness parameters and scored between 0 and 14. NEWS is a scoring scale consisting of the parameters of systolic blood pressure, respiratory rate, oxygen saturation, need for any suplemental oxygen, body temperature and state of consciousness and scored between 0 and 20. The NEWS-2 is a scoring scale consisting of systolic blood pressure, respiratory rate, oxygen saturation, presence of hypercapnia, need for oxygen therapy, body temperature, pulse rate, and state of consciousness and scored between 0 and 20. qSOFA is a scoring scale consisting of consciousness status, systolic blood pressure, respiratory rate parameters and scored between 0 and 3. REMS is a scoring scale consisting of age, mean arterial pressure, heart rate, respiratory rate, peripheral oxygen saturation, and state of consciousness, and scored between 0 and 26. Each scoring was calculated via a web-based calculator (www.mdcalc.com).

Statistical Analysis

Data were analyzed using IBM SPSS Statistics 26.0 for windows (IBM Corp., Armonk, New York, USA) statistical software suite. When evaluating variables according to the need for ICU; the independent samples t-test was used for age, respiratory rate, temperature, SBP, MAP, pulse rate, oxygen saturation, NEWS, NEWS-2, and REMS; and the Mann-Whitney U test was used for DBP, GCS, MEWS, qSOFA. Yates' Continuity Correction of the Chi-Squared test was used to examine the association between ICU admission status, sex and assisted ventilation, and Pearson's Chi-squared test was used to examine the association between ICU admission status and consciousness. In evaluating variables by mortality; the independent samples t-test was used for evaluating age, respiratory rate, SBP, DBP, MAP, pulse rate, oxygen saturation, NEWS and REMS, and the Mann-Whitney U test was used to evaluate temperature, GCS, MEWS, NEWS-2, and qSOFA. The association between mortality, sex, assisted ventilation, and consciousness was evaluated using Pearson's Chi-squared test. Statistical significance was set at $p<0.05$.

RESULTS

The patient flow chart, which shows inclusion and exclusion steps, is given in **Figure 1**. Among the 600 patients included, 365 (60.8%) were men and 235 (39.2%) were women. The mean age of the patients was 67.13±15.24 years. A total of 540 (90%) patients were admitted to the general ward and 60 (10%) were admitted to the ICU. Furthermore, 222 (37%) patients died and 378 (67%) patients were discharged. The characteristics of the sample and the breakdown of scores by patient outcome are provided in **Table 1**.

ROC analysis was performed to evaluate the value of MEWS, NEWS, NEWS-2, REMS, and qSOFA scoring systems in predicting the need for ICU admission in patients with COVID-19 (AUC:0.776, 0.778, 0.763, 0.758, and 0.724, respectively) (**Figure 2**). ROC analysis found a cut-off value of 2.5 for MEWS, 4.5 for NEWS, 4.5 for NEWS-2, 5.5 for REMS and 0.5 for qSOFA. The scoring systems' negative predictive values (NPV) at indicated specificity and sensitivity for predicting ICU admission were 0.95, 0.98, 0.97, 0.96, and 0.96 respectively, and were found to be statistically significant (p<0.001) (**Table 2**). When patients were divided into two groups as those at high and low risk for ICU admission according to the specified cut-off values, the high risk categorization for each scoring system was associated with ICU admission (p<0.001).

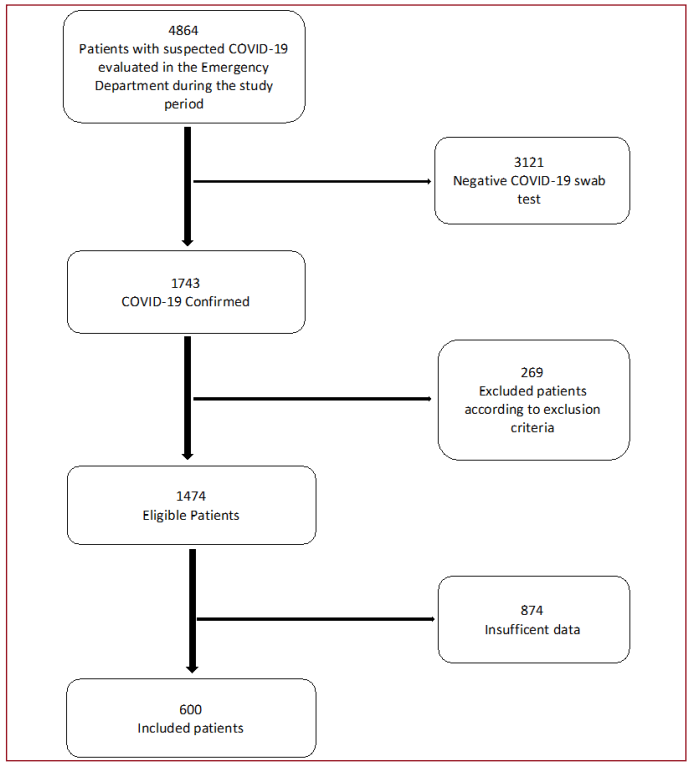

Figure 1. Patient flow chart

Table 1: Characteristics of the sample and breakdown of scores by patient outcome.

	All Patients (n=600)	Need for ICU			Mortality		
		No (n=540 [90%])	Yes (n=60 [10%])	P	Survived (n=378 [63%])	Dead (222 [37%])	P
Age (year)	67.13 ± 15.24	66.8 ± 15.47	70.17 ± 12.73	0.061+	65.45 ± 16.57	70 ± 12.18	<0.001+
Sex				0.780			0.993**
Male	365 (60.8)	327 (60.6)	38 (63.3)		230 (60.8)	135 (60.8)	
Female	235 (39.2)	213 (39.4)	22 (36.7)		148 (39.2)	87 (39.2)	
Respiratory rate	20.52 ± 5.38	19.74 ± 4.45	27.53 ± 7.6	<0.001+	19.78 ± 4.94	21.77 ± 5.87	<0.001+
Assisted ventilation				<0.001.			0.001**
No	247 (41.2)	235 (43.5)	12 (20)		175 (46.3)	72 (32.4)	
Yes	353 (58.8)	305 (56.5)	48 (80)		203 (53.7)	150 (67.6)	
Temperature	36.5 (36.1–36.8)	36.5 (36.1–36.8)	36.7 (36.1–37)	0.353*	36.5 (36.1–36.8)	36.5 (36.1–37)	0.236*
SBP	127.82 ± 21.39	127.25 ± 20.56	132.9 ± 27.47	0.127+	128.5 ± 20.7	126.65 ± 22.53	0.306+
DBP	71 (62–80)	72.5 (68–80)	70 (55–75)	0.372*	74.91 ± 13.81	73.46 ± 13.17	0.207+
MAP	92.18 ± 14.63	92.08 ± 14.25	93.1 ± 17.77	0.669+	92.77 ± 14.67	91.19 ± 14.53	0.203+
Pulse	90.31 ± 17.45	89.8 ± 16.71	94.9 ± 22.73	0.096+	89.31 ± 16.75	92.02 ± 18.5	0.066+
Consciousness				<0.001**			0.053**
Conscious	576 (96)	525 (97.2)	51 (85)		368 (97.4)	208 (93.7)	
Confused	19 (3.2)	14 (2.6)	5 (8.3)		7 (1.9)	12 (5.4)	
Unconscious	5 (0.8)	1 (0.2)	4 (6.7)		3 (0.8)	2 (0.9)	
GCS	15 (15–15)	15 (15–15)	15 (15–15)	<0.001*	15 (15–15)	15 (15–15)	0.003*
O2_saturation	94.31 ± 3.72	94.46 ± 3.51	92.95 ± 5.1	0.028+	94.93 ± 3.19	93.27 ± 4.3	<0.001+
MEWS	2 (1–3)	1.5 (1–2)	3 (2–3)	<0.001*	2 (1–2)	2 (1–3)	<0.001*
NEWS	4.43 ± 2.66	4.16 ± 2.56	6.83 ± 2.39	<0.001+	3.85 ± 2.44	5.4 ± 2.74	<0.001+
NEWS-2	4.45 ± 2.7	4.18 ± 2.58	6.8 ± 2.62	<0.001+	5 (3.25–7.75)	6 (4–8)	<0.001*
REMS	5.51 ± 2.5	5.26 ± 2.35	7.78 ± 2.69	<0.001+	5.11 ± 2.53	6.18 ± 2.31	<0.001+
qSOFA	1 (0–1)	1 (0–1)	1 (1–1)	<0.001*	1 (0–1)	1 (0–1)	<0.001*

Distribution percentages for sex, assisted ventilation and consciousness variables were given as column percentages. + Independent Samples t-test; * Mann–Whitney U Test Continuity Correction Yates Chi Square Test; ** Pearson Chi Square Test, ICU:Intensive care unit, SBP:Systolic blood pressure, DBS:Diastolic blood pressure, MAP:Mean arterial pressure, GCS:Glascow coma scale, MEWS: Modified early warning score, NEWS: National early warning score, NEWS 2: National early warning score 2, qSOFA: Quick sequential organ failure assessment

Table 2: Scoring Systems' Sensitivity and Specificity for Intensive Care Admission

	Sensitivity	Specificity	PPV	NPV	P
MEWS	0.66	0.791	0.26	0.95	<0.001
NEWS	0.917	0.587	0.19	0.98	<0.001
NEWS 2	0.883	0.583	0.19	0.97	<0.001
REMS	0.833	0.513	0.16	0.96	<0.001
qSOFA	0.800	0.615	0.19	0.96	<0.001

MEWS: Modified early warning score, NEWS: National early warning score, NEWS 2: National early warning score 2, qSOFA: Quick sequential organ failure assessment PPV: Positive predictive value, NPV: Negative predictive value

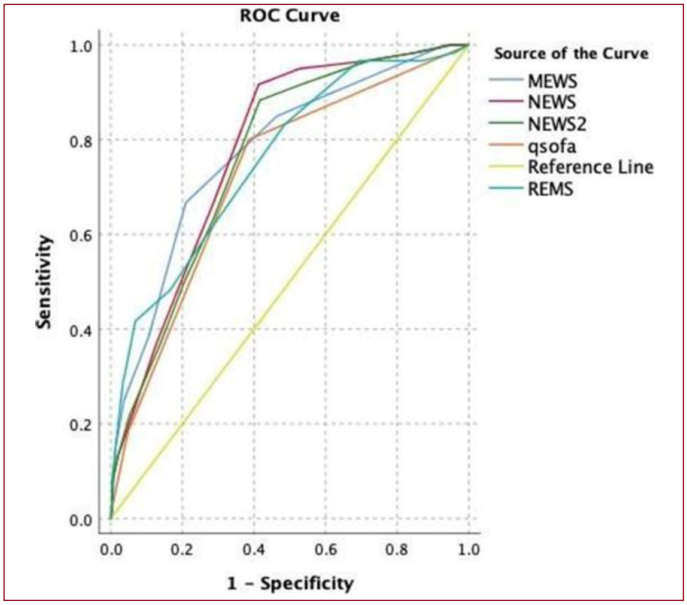

Figure 2. ROC Analysis of Scoring Systems for ICU Admission

ROC analysis was performed to evaluate the value of MEWS, NEWS, NEWS-2, REMS, and qSOFA scoring systems in predicting mortality in patients with COVID-19 (AUC:0.588, 0.658, 0.654, 0.638, and 0.577, respectively) (**Figure 3**). ROC analysis found a cut-off value of 1.5 for MEWS, 3.5 for NEWS, 3.5 for NEWS-2, 5.5 for REMS and 0.5 for qSOFA. The scoring systems' NPV at indicated specificity and sensitivity for predicting mortality were 0.61, 0.67, 0.67, 0.66, and 0.61 respectively, and were statistically significant (p<0.001) (**Table 3**). When patients were divided into two groups as those at high risk and low risk for mortality according to the specified cut-off values, the high risk categorization for each scoring system was associated with mortality (p<0.001) (**Table 2**).

Table 3: Scoring Systems' Sensitivity and Specificity for In-Hospital Mortality

	Sensitivity	Specificity	PPV	NPV	P
MEWS	0.566	0.547	0.50	0.61	<0.001
NEWS	0.689	0.526	0.53	0.67	<0.001
NEWS 2	0.685	0.523	0.53	0.67	<0.001
REMS	0.637	0.571	0.54	0.66	<0.001
qSOFA	0.502	0.634	0.52	0.61	<0.001

MEWS: Modified early warning score, NEWS: National early warning score, NEWS 2: National early warning score 2, qSOFA: Quick sequential organ failure assessment, PPV: Positive predictive value, NPV: Negative predictive value

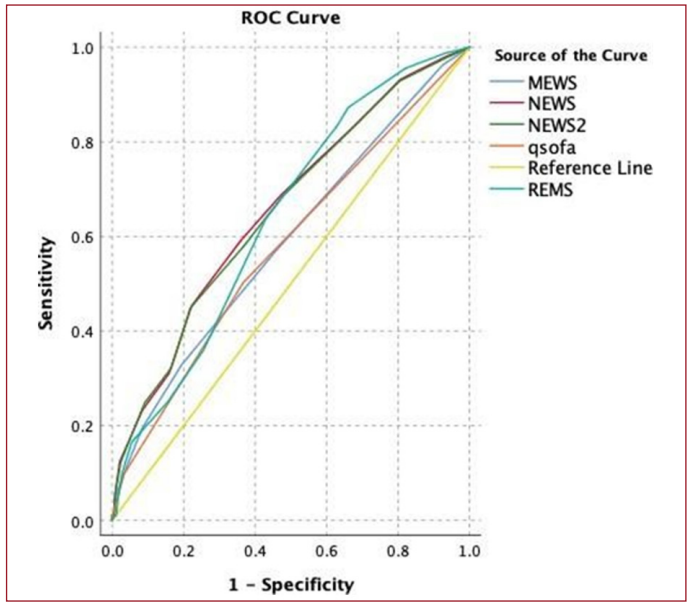

Figure 3. ROC Analysis of Scoring Systems for In-Hospital Mortality

DISCUSSION

Results of the present study demonstrated that MEWS, NEWS, NEWS 2, REMS and qSOFA early warning scoring systems were successful in predicting ICU admission and mortality for patients with COVID-19 who presented to the ED.

MEWS is a scoring system designed primarily for nurses to detect deterioration in patients. In addition, it can be used by any health professional with adequate training. This scoring system allows for the early detection of clinical deterioration and need for transition to ICU (14). One study by Covino et al. (15) found that MEWS was successful in excluding the need for ICU in patients with COVID-19 (Sensitivity:70, NPV:92.5), but was not associated with mortality. In the present study, we found that MEWS was similarly successful in excluding the need for ICU (sensitivity:0.66, specificity:0.79 and NPV:95); however, it was also significantly associated with mortality, despite low sensitivity and specificity (sensitivity:0.56, specificity:0.54).

NEWS has been originally developed to standardize assessments in the United Kingdom for early detection of clinical deterioration in patients. In this scoring system, patients with low scores can continue to receive usual care and monitoring, while patients with high scores should be considered for transition to ICU (16). One study by Smith et al. (16) that evaluated 35,585 patients in the United Kingdom and compared NEWS with 33 other EWS found NEWS to be superior to other scoring systems in predicting ICU admission and mortality in patients with COVID-19. The present study found that NEWS to be highly successful in both predicting and excluding the need for ICU admission (Sensitivity:0.917, NPV:0.98) and predicting and excluding mortality (Sensitivity:0.818, NPV:0.991). This result is in line with the literature.

In 2019, Smith et al. (17) added hypercapnic respiratory failure to NEWS parameters; the updated version, called NEWS-2, could can also be used for people with type 2 respiratory failure. However, hypercapnia is known to be rare in patients with COVID-19 including those admitted to the ICU (15, 18); furthermore, hypoxia caused by early pulmonary involvement is the most common clinical outcome in the course of the disease (19). Covino et al. (15) found that NEWS and NEWS-2 had similar effectiveness in predicting the need for ICU in COVID-19 patients, but NEWS was more successful than NEWS-2 in predicting mortality. Our study found that NEWS was more successful than NEWS-2 in predicting the need for ICU, while both had similar effectiveness in predicting mortality. The difference between these results can be explained by the length of follow-up: Covino et al based their assessments on ICU admission and mortality within 48 hours, while our study evaluated in-hospital ICU admission and mortality without any time restrictions.

REMS is used in pre-hospital settings to determine whether a patient can benefit from prompt access to advanced life support; and it is calculated with pre-hospital values or without laboratory tests (12). Covino et al. (15) found REMS to be a significant predictor of ICU admission and mortality, and showed that REMS had a high sensitivity (0.909) and NPV (0.99) for mortality. The present study also found REMS to be a significant predictor of ICU admission, with a sensitivity of 0.86, and a NPV of 0.96. However, for mortality, REMS was significant, but had low sensitivity and NPV (Sensitivity:0.637, NPV:0.66). This is thought to be caused by different length of follow-up in these two studies. Covino et al based their assessments on ICU admission and mortality within 48 hours, while our study evaluated in-hospital ICU admission and mortality without any time restrictions.

qSOFA scoring was designed as a simple and quick tool to predict mortality in patients with sepsis (20). Covino et al. (15) found that qSOFA was successful in predicting mortality in patients with COVID-19, but was clinically insignificant in predicting ICU admission (p=0.066). In the present study, qSOFA was found to be clinically significant in predicting both ICU admission and mortality, and was more successful in predicting ICU admission. qSOFA had a sensitivity of 0.80 and a NPV of 0.96 for ICU admission, and a sensitivity of 0.50 and a NPV of 0.61 for mortality. In the region where our hospital is located, there is a large number of elderly people and nursing homes. As a result, there is a high number of patients with dementia and neurological sequelae in our patient population. Therefore, altered mental status, one of the parameters in qSOFA, is seen frequently and this explains why qSOFA was significant in predicting the need for admission to ICU.

This study has some limitations as follows: EWS in the present study were calculated using patients' data from the first arrival at the ED, and the study ended with a single evaluation. However, repeated assessments at different time points could yield different results. Another limitation is the retrospective nature of the study. Prospective and multicenter studies are needed.

CONCLUSIONS

MEWS, NEWS, NEWS-2, REMS, and qSOFA, known as early warning scoring systems, were found to be clinically significant in identifying patients in need of ICU. High NPVs for each score indicates that these tools can be used for identifying patients who do not need ICU admission. MEWS, NEWS, NEWS-2, REMS, and qSOFA were clinically significant in predicting mortality. However, they were found to have low PPV and NPV, and this suggests that they cannot be used as stand-alone tools for predicting mortality, but can be helpful when used in conjunction with clinical evaluation.

ETHICAL DECLARATIONS

Ethics Committee Approval: The study was carried out with the permission of İzmir Katip Çelebi University Non-Intervential Clinical Trials Ethics Committee (Date: 27/05/2021, Decision No: 0265).

Informed Consent: All patients signed the free and informed consent form.

Referee Evaluation Process: Externally peer-reviewed.

Conflict of Interest Statement: The authors have no conflicts of interest to declare.

Financial Disclosure: The authors declared that this study has received no financial support.

Author Contributions: All of the authors declare that they have all participated in the design, execution, and analysis of the paper, and that they have approved the final version.

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