Original Article

Access this article online
Quick Response Code:

Website:
https://eurasianjpulmonol.org
DOI:
10.14744/ejp.2022.2004

Predictive value of early warning scores for clinical deterioration and mortality in hospitalized COVID-19 pneumonia patients

Umut Sabri Kasapoğlu, Leman Acun Delen[1], Abdullah Gök[1]

ORCID:
Umut Sabri Kasapoglu: 0000-0003-2869-9872
Leman Acun Delen: 0000-0001-9441-6979
Abdullah Gok: 0000-0002-1407-8437

Abstract:

BACKGROUND AND AIM: The most important step in inpatient management to prevent mortality in COVID-19 patients is to diagnose clinical deterioration early and quickly. Early warning score (EWS) systems evaluate vital signs to detect early deterioration in a patient's clinical status. The aim of this study was to see how accurate the EWS is at predicting the need for a transfer to the intensive care unit (ICU) and the mortality in COVID-19 pneumonia patients who are hospitalized.

METHODS: A total of 471 confirmed COVID-19 pneumonia patients treated in our COVID-19 wards were included in the present study.

RESULTS: ICU admission occurred in 95 (20.1%) of the cases during hospitalization, with a death rate of 11.9%. Compared with patients who were not admitted to the ICU, those who were admitted had higher National Early Warning Score (NEWS), NEWS2, Modified Early Warning Score (MEWS), and Quick Sequential Organ Failure Assessment (qSOFA) score ($p<0.001$). NEWS was found to be superior to NEWS2, MEWS, and qSOFA in predicting patient clinical deterioration ($p<0.001$). NEWS outperformed NEWS2, MEWS, and the qSOFA score in predicting overall hospital mortality ($p<0.05$). ICU admission was substantially associated with high NEWS (≥7) and NEWS2 (≥7) ($p=0.001$, $p=0.0028$).

CONCLUSIONS: NEWS and NEWS2 could be used routinely in pandemic wards to detect clinical worsening in COVID-19 pneumonia patients who are hospitalized.

Keywords:

COVID-19, clinical deterioration, early warning score system, intensive care unit

Department of Pulmonary and Critical Care Medicine, Malatya Training and Research Hospital, Malatya, Türkiye, [1]Department of Anaesthesiology and Reanimation, Malatya Training and Research Hospital, Malatya, Türkiye

Address for correspondence:
Dr. Umut Sabri Kasapoğlu, Department of Pulmonary and Critical Care Medicine, Malatya Training and Research Hospital, Malatya, Türkiye.
E-mail: umutkasapoglu@gmail.com

Received: 14-02-2022
Revised: 11-08-2022
Accepted: 08-09-2022
Published: 20-10-2022

How to cite this article: Kasapoğlu US, Acun Delen L, Gök A. Predictive value of early warning scores for clinical deterioration and mortality in hospitalized COVID-19 pneumonia patients. Eurasian J Pulmonol 2022;24:169-78.

Introduction

Severe acute respiratory syndrome coronavirus-2 (SARS-CoV-2) causes the novel coronavirus disease-2019 (COVID-19), which has a broad-spectrum clinical presentation. In large clinical series, it has been reported that the disease progresses with mild symptoms in 81% of the cases.[1,2] Severe disease accompanied by life-threatening respiratory failure may develop in approximately 5% of the patients, and the mortality rate is higher in this patient group.[1–3]

Vital signs may deteriorate rapidly in COVID-19 patients during hospitalization.[4] The most crucial step in the management of COVID-19 patients who are hospitalized is the early and rapid diagnosis of clinical deterioration to reduce mortality[2,3,5] because clinical studies have shown that abnormal physiological parameters measured in hospitalized patients are linked to a longer length of hospital stay and a higher mortality rate.[6,7]

Early warning score (EWS) system enables the evaluation of risky patients by a systematic approach and early detection of deterioration in the clinical picture of the patients. EWS includes physiological scoring systems based on quick and quantitative assessment of changes in vital signs.[8–10] The World Health Organization (WHO) recommends using EWS for early detection of deterioration in the clinical picture of COVID-19 patients for earlier intervention.[5]

The present study aimed to assess and compare the applicability of EWS in predicting clinical worsening, intensive care unit (ICU) admission, and mortality in COVID-19 pneumonia patients who were hospitalized in the COVID-19 pandemic.

Materials and Methods

We conducted a prospective observational study in the COVID-19 wards of Malatya Training and Research Hospital between January 15 and February 15, 2021. Patients diagnosed with COVID-19 pneumonia and admitted to COVID-19 pandemic clinics for more than 24 h were evaluated by the point prevalence method at the same hour on four different days of four consecutive weeks with 1-week intervals. A total of 471 confirmed COVID-19 pneumonia patients treated in our COVID-19 general ward were enrolled in the present study.

Exclusion and inclusion criteria

Patients with >18 years of age, confirmed COVID-19 pneumonia patients, and patients with ≥24 h of hospital stay were included in the study. Exclusion criteria in the present study include patients who were <18 years old, suspected COVID-19 patients, non-COVID-19 patients, patients without COVID-19 pneumonia, patients with missing data, patients with <24 h hospital stay, and patients transferred to other hospitals.

Data collection and definitions

We included physiological and laboratory parameters that were routinely obtained at hospital admission and during the hospital stay. The following patient's data were collected and analyzed: all patients' demographics and comorbidities, physiological data (including heart rate (beats/min), body temperature (°C), diastolic blood pressure (mmHg), systolic blood pressure (mmHg), oxygen saturation (%), respiratory rate (breaths/min), and Glasgow Coma Scale), laboratory parameters (complete blood count, glucose, urea, creatinine, albumin, aspartate aminotransferase, alanine transaminase, lactate dehydrogenase, creatine kinase, total bilirubin, C-reactive protein (CRP), procalcitonin, N-terminal-pro-brain natriuretic peptide (NT-proBNP), D-dimer, ferritin, cardiac troponin I (cTnI), and fibrinogen), types of respiratory support (nasal cannula oxygen therapy, simple facemask oxygen therapy, and non-rebreather facemask oxygen therapy), hospital length of stay (LOS), outcomes, scores on the Modified Early Warning Score (MEWS), National Early Warning Score (NEWS), NEWS2, and Quick Sequential Organ Failure Assessment (qSOFA). We obtained all laboratory data from the hospital's medical record system.

A confirmed case of SARS-CoV-2 infection was defined as follows: a symptomatic case with positive SARS-CoV-2 real-time reverse transcription-polymerase chain reaction from the nasopharyngeal and/or oropharyngeal swab. Also, the COVID-19 pneumonia case was defined as a symptomatic confirmed COVID-19 case with pulmonary infiltrates in thorax computed tomography (CT).[11]

The NEWS was developed by the Royal College of Physicians in 2012. It includes seven physiological parameters: respiratory rate, oxygen saturations, any supplemental oxygen, body temperature, systolic blood pressure, heart rate, and level of consciousness according to the alert,

voice, pain, unresponsive (AVPU) score. NEWS is categorized into three categories: low (1–4), medium (5–6), and high (≥7) clinical risk.[7]

NEWS2 includes six physiological parameters: heart rate, body temperature, respiratory rate, room air or supplemental oxygen, systolic blood pressure, and level of consciousness according to the AVPU score. NEWS2 is categorized into three clinical risk categories: low (0–4), medium (5–6), and high.[5,7]

MEWS was developed in 2001 by Subbe et al.,[12] and it includes five physiological parameters: respiratory rate, body temperature, systolic blood pressure, heart rate, and level of consciousness according to the AVPU score. A MEWS5 score has been associated with an increased likelihood of ICU admission.

Seymour et al.[13] created the SOFA score in 2016 to identify high-risk patients for inhospital mortality with suspected infection outside the ICU. It includes three physiological parameters: respiratory rate (≥22 breaths/min), systolic blood pressure (≤100 mmHg), and Glasgow Coma Scale (<15). If any of these two variables are positive, the patient is considered qSOFA positive. In patients with suspected infection, a "positive" qSOFA score (≥2) indicates a high likelihood of a poor outcome.

Measurement of outcome

We followed up with all patients during their hospital stay or until their death in the hospital. Also, we collected mortality data of the patients from the hospital medical record system.

Ethics

This clinical study was approved by the Republic of Turkey Ministry of Health and Clinical Ethics Committee of Inonu University Faculty of Medicine and fulfilled the Declaration of Helsinki (protocol no.: 2020/16).

Statistical analysis

We used SPSS (Statistical Package for Social Sciences, SPSS, Inc., Chicago, IL, USA) for Windows 26.0 program for the statistical analysis. We used Skewness-Kurtosis to evaluate the distribution and homogeneity of the variables. The continuous variables were shown as mean±standard deviation. The nonnormally and nonhomogeneous distributed variables were shown as min–max values by numbers. The categorical variables were shown as frequency and percentages. The parametric data were analyzed using the independent samples t-test, while the nonparametric data were analyzed using the Mann-Whitney U test. The Chi-squared test was used for the analysis of categorical data. The area under the receiver operating characteristic (ROC) curve was calculated to assess the predictive performance of the EWSs for predicting ICU transfer and hospital mortality. Multiple logistic regression analysis was performed to predict ICU admission and hospital mortality with each EWS as a covariate. The results were assessed at a 95% confidence interval, with a value of $p<0.05$ considered statistically significant.

Results

Baseline clinical characteristics of the study population

Between January 15 and February 15, 2021, a total of 471 patients with COVID-19 pneumonia were included in the present study. Of the patients, 266 (56.5%) were males, and the mean age of the patients was found to be 68.11±13.89 years. Hypertension (43.9%), coronary artery disease (27.0%), and diabetes mellitus (24.4%) were the most common comorbidities.

It was determined that admission to ICU developed in 95 (20.1%) cases during hospitalization, the hospital mortality was 11.9%, and the mean LOS in the hospital was 13.39±9.09 days. Table 1 shows the baseline demographic and clinical characteristics of the study population. Baseline laboratory findings of the study population are presented in Table 2.

In the present study, the patients were divided into two groups: those who were admitted to the ICU (n=95, 20.1%) and those who did not (n=376, 79.8%). It was found that the presence of comorbidities, including congestive heart failure (p=0.018), coronary artery disease (p=0.001), arrhythmia (p=0.035), and dementia (p=0.001), were frequent in patients who were admitted to the ICU. When the two groups were compared in terms of vital signs, it was determined that the mean respiratory rate (p<0.001) was higher, whereas peripheral oxygen saturation (p<0.001) and systolic (p=0.001) and diastolic (p=0.003) blood pressure were lower in patients transferred to the ICU. On the other hand, it was determined that NEWS, NEWS2, MEWS, and qSOFA score were significantly higher in the ICU group compared with the non-ICU group (p<0.001) (Table 1).

Table 1: Baseline characteristics of the patients

	All patients (n=471)		Admitted to ICU				p
			No (n=376)		Yes (n=95)		
	n	%	n	%	n	%	
Age (years)	68.11±13.89		66.40±13.68		74.88±12.64		**<0.001**
Gender							
Male	266	56.5	211	56.1	55	57.9	0.755
Female	205	43.5	165	43.9	40	42.1	
Comorbidities							
HT	207	43.9	154	41.0	53	55.8	**0.009**
CAD	127	27.0	88	23.4	39	41.1	**0.001**
DM	115	24.4	89	23.7	26	27.4	0.453
COPD	77	16.3	64	17.0	13	13.7	0.432
Dementia	43	9.1	26	6.9	17	17.9	**0.001**
CHF	37	7.9	24	6.4	13	13.7	**0.018**
Arrhythmia	28	5.9	18	4.8	10	10.5	**0.035**
CVD	16	3.4	15	4.0	1	1.1	0.158
CKD	10	2.1	9	2.4	1	1.1	0.418
Malignancy	6	1.3	4	1.1	2	0.4	0.419
Vital signs							
Heart rate (beats/min)	79.23±12.43		78.79±11.95		80.95±14.12		0.131
Respiratory rate (breaths/min)	21.77±3.75		21.30±3.62		23.65±3.68		**<0.001**
Systolic blood pressure (mmHg)	116.86±15.52		118.04±15.03		112.21±16.59		**0.001**
Diastolic blood pressure (mmHg)	71.80±10.17		72.50±9.65		69.05±11.67		**0.003**
Glasgow Coma Scale	15 (10–15)		15 (10–15)		15 (10–15)		0.455
Body temperature (°C)	36.42±0.37		36.39±0.37		36.52±0.37		**0.005**
Peripheral oxygen saturation (%)	92.66±3.60		93.13±3.38		90.80±3.82		**<0.001**
Supplemental oxygen therapy							
Nasal cannula	251	53.3	230	61.2	21	22.1	**<0.001**
Non-rebreather face mask	166	35.2	101	26.9	65	68.4	**<0.001**
Simple face mask	54	11.5	45	12.0	9	9.5	0.495
Early warning scores							
NEWS	6.39±2.56		5.70±2.05		9.08±2.60		**<0.001**
NEWS2	4.79±2.08		4.23±1.63		7.00±2.20		**<0.001**
MEWS	2.00 (0–8)		2 (0–6)		3 (1–8)		**<0.001**
qSOFA	0.93±0.78		0.76±0.65		1.63±0.85		**<0.001**
Hospital LOS (days)	13.39±9.09		12.10±7.18		18.26±13.15		**<0.001**
Hospital mortality							
Survivors	415	88.1	365	97.8	50	52.6	**<0.001**
Nonsurvivors	56	11.9	11	2.9	45	47.4	

ICU: Intensive care unit, HT: Hypertension, CAD: Coronary artery disease, DM: Diabetes mellitus, COPD: Chronic obstructive pulmonary disease, CHF: Chronic heart failure, CVD: Cerebrovascular disease, CKD: Chronic kidney disease, NEWS: National Early Warning Score, NEWS2: National Early Warning Score 2, MEWS: Modified Early Warning Score, qSOFA: Quick Sequential Organ Failure Assessment, LOS: Length of stay.

In the evaluation of the laboratory data on the day when the EWSs of the cases were calculated, it was determined that serum CRP (p=0.019) and urea (p=0.043) levels were statistically significantly higher in the ICU group compared with the non-ICU group. The comparison of the laboratory findings between the groups is given in Table 2.

Clinical deterioration and mortality prediction performance of the EWSs

In the present study, ROC analysis was used to predict the patients' clinical deterioration and mortality. Analysis of the ROC showed that NEWS (AUC=0.840, p<0.001) was superior to the NEWS2 (AUC=0.837, p<0.001), MEWS (AUC=0.790, p<0.001), and qSOFA score (AUC=0.770, p<0.001) for the prediction of patients' clinical deterioration. For clinical deterioration prediction, among the EWSs, NEWS was found to be the most accurate scoring system [Fig. 1]. Multivariate logistic regression analysis showed that high NEWS (≥7) and NEWS2 (≥7) were significantly related to ICU admission (p<0.001, OR=3.349, 95% CI=1.752–6.402 and p=0.028, OR=3.623, 95% CI=1.148–11.433) (Table 3).

Table 2: Baseline laboratory findings of the patients

	All patients (n=471)	Admitted to ICU		p
		No (n=376)	Yes (n=95)	
Biochemical parameters				
Glucose, mg/dL (min-max)	130 (62–614)	128 (62–614)	138 (72–602)	0.389
Urea, mg/dL (min-max)	43 (10–228)	42 (10–228)	48 (17–205)	**0.043**
Crea, mg/dL (min-max)	0.94 (0.30–9.01)	0.93 (0.30–9.01)	0.95 (0.30–2.76)	0.275
AST, U/L (min-max)	36 (9–213)	36 (9–213)	11 (11–170)	0.924
ALT, U/L (min-max)	24 (5–171)	24 (5–171)	22 (6–104)	0.175
Total bilirubin, g/dL (min-max)	0.52 (0.07–4.01)	0.52 (0.07–4.01)	0.51 (0.17–1.75)	0.943
CK, U/L (min-max)	110 (1–1000)	108 (1–1000)	122 (17–1000)	0.102
LDH, IU/L (mean±SD)	410.79±172.09	403.29±169.90	439.15±178.42	0.102
Albumin, g/dL (min-max)	3.10 (1.20–6.75)	3.10 (1.20–6.75)	3.10 (2.20–4.38)	0.382
Inflammatory parameters				
Ferritin, ng/dL (min-max)	414 (12–2000)	418 (12–2000)	372 (23–2000)	0.995
CRP, mg/dL (mean±SD)	8.41±7.04	7.97±6.77	10.06±7.78	**0.019**
PCT, ng/mL (min-max)	0.14 (0.01–2056)	0.13 (0.01–13.23)	0.16 (0.02–20.56)	0.063
Total blood count				
WBC, 10^3 μL^{-1} (mean±SD)	7.27±6.73	8.80±5.97	9.20±9.10	0.664
Neu, 10^3 μL^{-1} (min-max)	6.12 (0.73–23.44)	5.99 (0.75–18.83)	6.13 (0.73–23.44)	0.667
Lymph, 10^3 μL^{-1} (min-max)	1.09 (0.19–7.30)	1.10 (0.25–6.70)	1.04 (0.19–7.30)	0.903
Hgb, g/dL (mean±SD)	12.78±1.93	12.79±1.84	12.76±2.23	0.390
Htc, % (mean±SD)	39.42±5.60	39.47±5.44	39.24±6.23	0.916
Plt, 10^3 μL^{-1} (mean±SD)	238.53±90.12	240.55±93.66	230.90±75.23	0.401
Cardiac markers				
Trop-I, ng/mL (min–max)	0.1 (0.01–2.02)	0.1 (0.01–1.45)	0.1 (0.1–2.02)	0.051
NT-proBNP, pg/mL (min-max)	321 (12–35 000)	290 (2–35 000)	410 (32–35 000)	0.090
Coagulation parameters				
Fibrinogen, ng/dL (mean±SD)	428.11±148.02	425.30±148.99	433.29±152.27	0.679
D-dimer, µg/mL (min-max)	0.68 (0.03–8.90)	0.68 (0.03–8.90)	0.70 (0.10–7.15)	0.654

ICU: Intensive care unit, AST: Aspartate aminotransferase, ALT: Alanine transaminase, CK: Creatine kinase, LDH: Lactate dehydrogenas, CRP: C-reactive protein, PCT: Procalcitonin, WBC: White blood cell, Neu: Neutrophil, Lymph: Lymphocyte, Hgb: Hemoglobin, Htc: Hematocrit, PLT: Platelet, NT-proBNP: N-terminal-pro-brain natriuretic peptide.

For overall hospital mortality prediction, among these EWS systems, NEWS (AUC=0.709, p<0.001) was superior to the NEWS2 (AUC=0.690, p<0.001), MEWS (AUC=0.681, p<0.001), and qSOFA score (AUC=0.620, p=0.003) (Fig. 2 and Table 4). Multivariate logistic regression analysis revealed that only high NEWS (≥7) was significantly related to overall hospital mortality (p=0.001, OR=3.256, 95% CI=1.611–6.581) (Table 5).

Discussion

To the best of our knowledge, the present study is the first prospective cohort study to investigate the clinical deterioration and hospital mortality prediction performances of EWSs in hospitalized COVID-19 pneumonia patients. We investigated and compared the validity of the EWSs in predicting clinical worsening and mortality in hospitalized patients with the diagnosis of COVID-19 pneumonia. Our main finding was that among the hospitalized COVID-19 pneumonia patients, high NEWS (≥7) and NEWS2 (≥7) revealed significant accuracy for ICU admission compared with the qSOFA and MEWS. In addition, high NEWS (≥7) was also associated with increased mortality.

Clinical findings in COVID-19 can be seen in a wide range of illnesses, ranging from modest symptoms, including asymptomatic disease and moderate upper respiratory tract infection, to severe viral pneumonia with respiratory failure and the potential for mortality.[14] It has been shown that approximately 33% of COVID-19 patients require hospitalization in clinical studies.[15] However, it has been shown that approximately 15%–25% of COVID-19 patients requiring hospitalization develop critical illness requiring intensive care follow-up.[5,16–18]

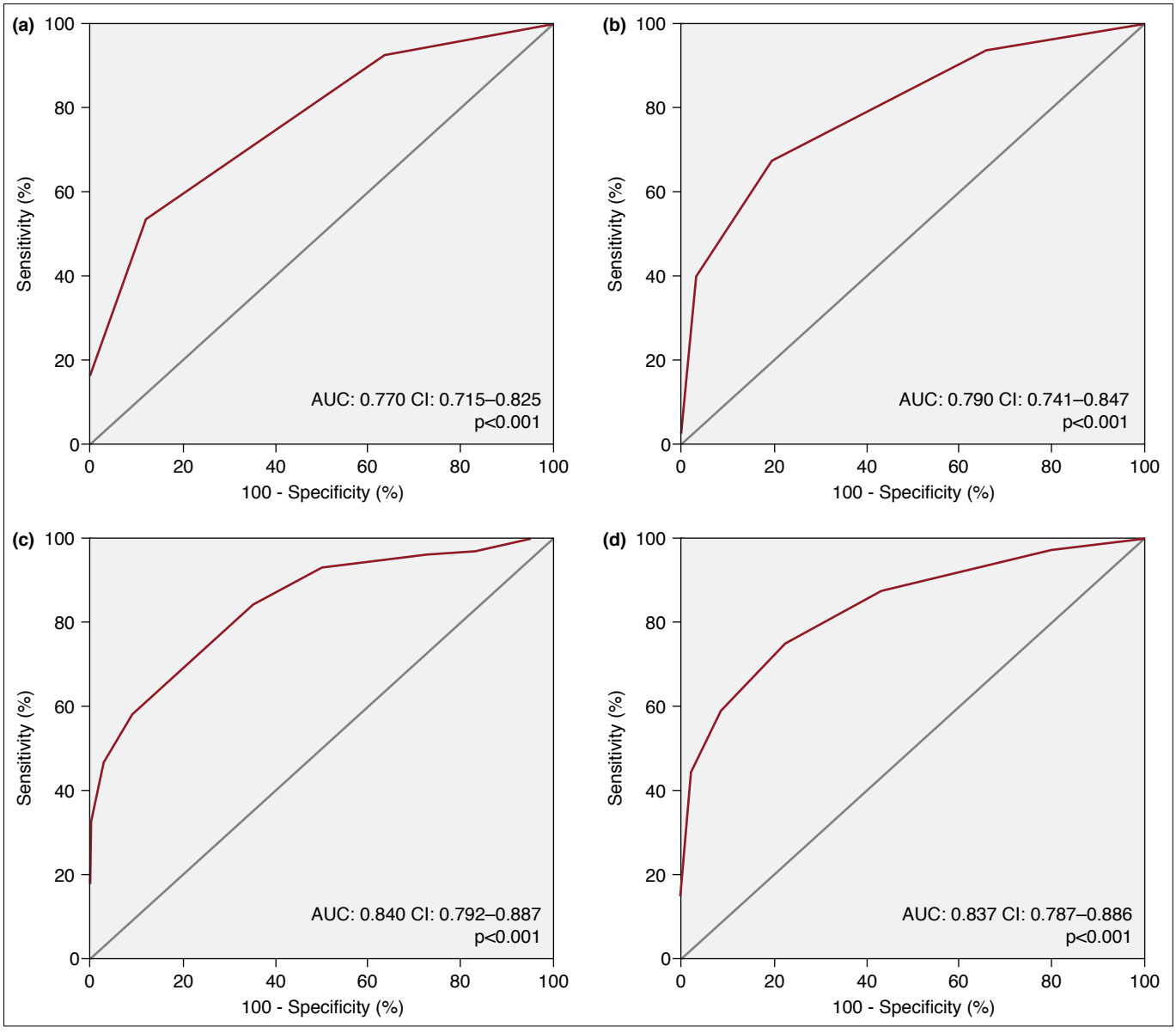

Figure 1: Receiver operator characteristic curve analysis of (a) qSOFA, (b) MEWS, (c) NEWS, and (d) NEWS2 for predicting ICU admission

AUC: Area under curve, CI: Confidence interval, qSOFA: Quick Sequential Organ Failure Assessment, MEWS: Modified Early Warning Score, NEWS: National Early Warning Score, NEWS2: National Early Warning Score 2, ICU: Intensive care unit

Although it has been stated that the general hospital mortality rates are around 10%–25% in hospitalized COVID-19 patients, it has also been shown that mortality is much higher in critically ill COVID-19 patients hospitalized in the ICU, in parallel with the increase in the severity of the disease.[14,17,19,20] In the present study, it was shown that in 95 (20.1%) of the cases, the need for intensive care developed during hospitalization, and the general hospital mortality was 11.9%. However, consistent with the literature, the rate of mortality was found to be significantly higher in the ICU patients compared with the non-ICU patients (47.4% vs 2.9%, p<0.001).

Early detection of the rapid deterioration in the clinical status of hospitalized COVID-19 cases and high-risk cases that need to be transferred to the ICU has been crucial during the pandemic. Because early detection of cases with life-threatening critical illness and early initiation of salvage treatment methods will significantly contribute to reducing the mortality associated with COVID-19.[20–23]

EWS systems have been developed to evaluate the vital signs of patients at risk and to detect clinical deterioration early and accurately with a systematic approach. It

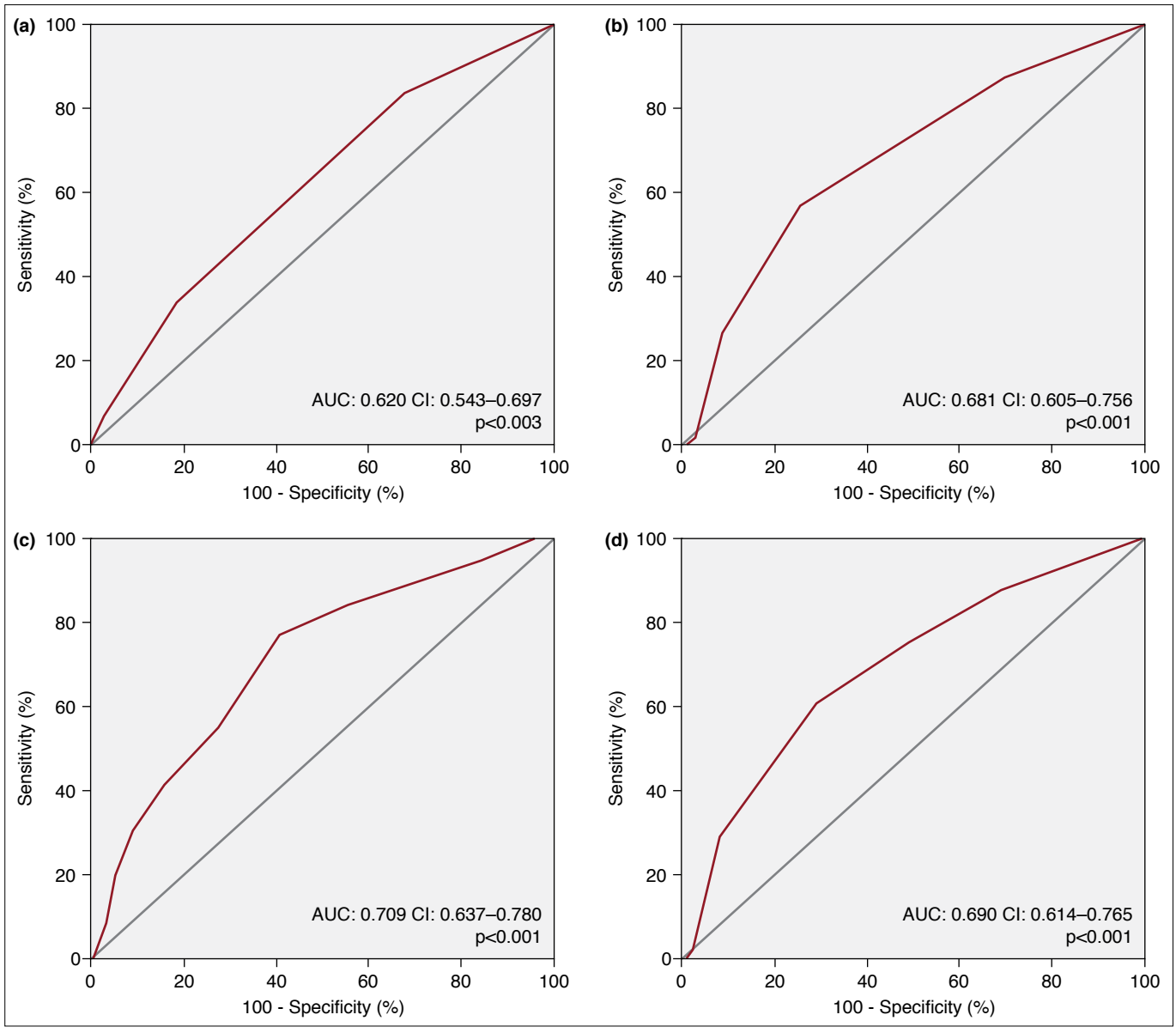

Figure 2: Receiver operator characteristic curve analysis of (a) qSOFA, (b) MEWS, (c) NEWS, and (d) NEWS2 for predicting overall hospital mortality

AUC: Area under curve, CI: Confidence interval, qSOFA: Quick Sequential Organ Failure Assessment, MEWS: Modified Early Warning Score, NEWS: National Early Warning Score, NEWS2: National Early Warning Score 2

has been shown in many studies that the effective clinical use of EWSs can reduce in-hospital cardiac arrests and ICU admissions significantly and result in significant improvement in mortality and morbidity. Therefore, during the COVID-19 pandemic, the WHO recommended using EWSs for early detection of clinical worsening in COVID-19 cases treated in pandemic services and for early intervention in cases of clinical worsening.[5,8–10,16,20]

The original study performed by Seymour et al.[13] showed that a qSOFA score of 2 or higher was associated with a significantly increased risk of hospital mortality

Table 3: Multivariate logistic regression analysis of the early warnings scores for predicting ICU admission

	OR	95% CI		p
		Lower bound	Upper bound	
NEWS2 (≥7)	3.623	1.148	11.433	0.028
NEWS (≥7)	3.349	1.752	6.402	<0.001
MEWS (≥3)	2.994	0.806	11.116	0.101
qSOFA (≥2)	1.307	0.419	4.078	0.645

ICU: Intensive care unit, OR: Odds ratio; CI: Confidence interval, NEWS2: National Early Warning Score 2, NEWS: National Early Warning Score, MEWS: Modified Early Warning Score, qSOFA: Quick Sequential Organ Failure Assessment.

Table 4: PPV, NPV, sensitivity, and specificity of the EWSs for the prediction of ICU admission and overall hospital mortality

	Prediction of ICU				Prediction of mortality			
	PPV (%)	NPV (%)	Sen (%)	Spe (%)	PPV (%)	NPV (%)	Sen (%)	Spe (%)
NEWS (≥7)	91.1	92.9	84.2	79.7	83.2	94.1	76.8	72.0
NEWS2 (≥7)	87.5	90.2	74.7	78.2	75.7	83.9	60.7	71.1
qSOFA (≥2)	73.7	78.3	53.7	88.1	73.9	71.4	57.3	82.6
MEWS (≥5)	71.4	81.4	67.4	71.9	71.8	85.4	57.1	75.9

PPV: Positive predictive value, NPV: Negative predictive value, EWSs: Early Warning Scores, ICU: Intensive care unit, Sen: Sensitivity, Spe: Specificity, NEWS: National Early Warning Score, NEWS2: National Early Warning Score 2, qSOFA: Quick Sequential Organ Failure Assessment, MEWS: Modified Early Warning Score.

in patients with sepsis. Although the use of qSOFA in the diagnosis of sepsis is still controversial, the authors need to emphasize that qSOFA is not a part of the definition of sepsis but rather a useful marker of early diagnosis of sepsis in the clinic and an "EWS system."[24,25] However, in recent observational studies, it has been shown that qSOFA is not as successful as the other EWSs in predicting clinical worsening and/or mortality in COVID-19 cases. However, it was shown that COVID-19 cases who were transferred to the ICU due to clinical deterioration had higher qSOFA scores. In addition, it has been shown that cases with a higher qSOFA score (≥2) have a higher risk of mortality.[3,26–29] It was found that patients who were admitted to the ICU had higher qSOFA score values compared with those who did not ($p<0.001$). On the other hand, it was found that qSOFA (≥2) was the least accurate scoring system in the prediction of clinical deterioration and mortality compared with the other EWSs. Also, it was found that qSOFA (≥2) was the least accurate scoring system in the prediction of clinical deterioration and mortality compared with the other EWSs.

MEWS has been developed by Subbe et al.[12] to identify early clinical deterioration in hospitalized patients. The original validation study and other clinical studies showed that high MEWS has been associated with an increased risk of ICU admission in medical and surgical patients.[12,21,30] Similarly, clinical studies performed during the COVID-19 pandemic have been shown that COVID-19 patients who were transferred to the ICU and/or died due to clinical deterioration had higher MEWS values.[16,20–22]

However, the results of retrospective observational studies evaluating the validity of MEWS in predicting clinical worsening and mortality in COVID-19 patients were conflicting. Wang et al.[21] showed that MEWS can be used for the early detection of high-risk patients among hospitalized older COVID-19 cases. They also found that MEWS' hospital mortality prediction accuracy was

Table 5: Multivariate logistic regression analysis of the EWSs for predicting overall hospital mortality

	OR	95% CI		p
		Lower bound	Upper bound	
NEWS2 (≥7)	4.129	0.906	18.818	0.067
NEWS (≥7)	3.256	1.611	6.581	0.001
qSOFA (≥2)	0.377	0.083	1.714	0.207
MEWS (≥5)	0.263	0.032	2.142	0.212

EWSs: Early Warning Scores, OR: Odds ratio, CI: Confidence interval, NEWS2: National Early Warning Score 2, NEWS: National Early Warning Score, qSOFA: Quick Sequential Organ Failure Assessment, MEWS: Modified Early Warning Score.

as good as other prognostic scores, including qSOFA, Pneumonia Severity Index, SOFA, and Acute Physiological and Chronic Health Evaluation II score. On the other hand, other studies showed that MEWS was less accurate compared with NEWS and NEWS2 in predicting clinical deterioration and mortality in hospitalized COVID-19 patients. For this reason, it is not recommended to use MEWS as a screening tool for clinical deterioration prediction and mortality prediction in hospitalized COVID-19 patients.[16,20,22] In the present study, among all EWSs, MEWS and qSOFA had the lowest accuracy in identifying the clinical deterioration and hospital mortality in hospitalized COVID-19 pneumonia patients.

NEWS and NEWS2 have been widely used throughout Great Britain hospitals for identifying the clinical deterioration of hospitalized patients. Further clinical studies have shown that NEWS is more successful than other scoring systems in predicting transfer to the ICU and mortality.[16,22,28,29] The Royal College of Physicians has recommended the use of NEWS2 for the early detection of clinical worsening in COVID-19 patients who are hospitalized in the COVID-19 pandemic.[16] In clinical studies comparing the success of NEWS and NEWS2 with other EWSs in predicting clinical worsening and mortality in COVID-19 cases, it was shown that NEWS and NEWS2

were better predictors for detecting clinical worsening and mortality.[3,16,18,23,31] NEWS and NEWS2 had the largest AUC for predicting clinical deterioration and hospital mortality among these EWSs in the present study. Also, analysis of multivariate logistic regression revealed that NEWS was the most accurate EWS for predicting clinical deterioration (p<0.001, OR=3.349, 95% CI=1.752–6.402) and mortality (p=0.001, OR=3.256, 95% CI=1.611–6.581) in hospitalized COVID-19 pneumonia patients.

Conclusion

Among the hospitalized COVID-19 pneumonia patients, high NEWS (≥7) and NEWS2 (≥7) are the most accurate scoring systems for ICU admission compared with the qSOFA and MEWS. High NEWS (≥7) was also associated with increased mortality. Therefore, NEWS and NEWS2 could be used routinely as tools for the early recognition of clinical deterioration of hospitalized COVID-19 pneumonia patients in pandemic wards.

Conflicts of interest
There are no conflicts of interest.

Ethics Committee Approval
The study was approved by the Malatya Clinical Research Ethics Committee (No: 2021/16, Date: 03/02/2021).

Financial support and sponsorship
Nil.

Peer-review
Externally peer-reviewed.

Authorship Contributions
Concept – U.S.K., L.A.D., A.G.; Design – U.S.K., L.A.D., A.G.; Supervision – U.S.K., L.A.D., A.G.; Funding – L.A.D., U.S.K.; Materials – L.A.D., A.G.; Data collection &/or processing – U.S.K., L.A.D., A.G.; Analysis and/or interpretation – U.S.K., L.A.D.; Literature search – L.A.D.; Writing – U.S.K., L.A.D., A.G.; Critical review – U.S.K.

References

1. Rothan HA, Byrareddy SN. The epidemiology and pathogenesis of coronavirus disease (COVID-19) outbreak. J Autoimmun 2020;109:102433. [CrossRef]
2. Siddiqi HK, Mehra MR. COVID-19 illness in native and immunosuppressed states: A clinical-therapeutic staging proposal. J Heart Lung Transplant 2020;39:405–7. [CrossRef]
3. Jang JG, Hur J, Hong KS, Lee W, Ahn JH. Prognostic accuracy of the SIRS, qSOFA, and NEWS for early detection of clinical deterioration in SARS-CoV-2 infected patients. J Korean Med Sci 2020;35:e234.
4. Verity R, Okell LC, Dorigatti I, Winskill P, Whittaker C, Imai N, et al. Estimates of the severity of coronavirus disease 2019: a model-based analysis. Lancet Infect Dis 2020;20:669–77. [CrossRef]
5. Rigoni M, Torri E, Nollo G, Delle Donne L, Cozzio S. NEWS2 is a valuable tool for appropriate clinical management of COVID-19 patients. Eur J Intern Med 2021;85:118–20. [CrossRef]
6. Groarke JD, Gallagher J, Stack J, Aftab A, Dwyer C, McGovern R, et al. Use of an admission early warning score to predict patient morbidity and mortality and treatment success. Emerg Med J 2008;25:803–6. [CrossRef]
7. Atmaca Ö, Turan C, Güven P, Arıkan H, Eryüksel SE, Karakurt S. Usage of NEWS for prediction of mortality and in-hospital cardiac arrest rates in a Turkish university hospital. Turk J Med Sci 2018;48:1087–91. [CrossRef]
8. Smith GB, Prytherch DR, Meredith P, Schmidt PE, Featherstone PI. The ability of the National Early Warning Score (NEWS) to discriminate patients at risk of early cardiac arrest, unanticipated intensive care unit admission, and death. Resuscitation 2013;84:465–70.
9. Prytherch DR, Smith GB, Schmidt PE, Featherstone PI. ViEWS--Towards a national early warning score for detecting adult inpatient deterioration. Resuscitation 2010;81:932–7. [CrossRef]
10. Martín-Rodríguez F, Martín-Conty JL, Sanz-García A, Rodríguez VC, Rabbione GO, Cebrían Ruíz I, et al. Early warning scores in patients with suspected COVID-19 infection in emergency departments. J Pers Med 2021;11:170. [CrossRef]
11. World Health Organization (WHO). WHO COVID-19 case definition. Available at: https://www.who.int/publications/i/item/WHO-2019-nCoV-Surveillance_Case_Definition-2020.2. Accessed Dec 16, 2020].
12. Subbe CP, Kruger M, Rutherford P, Gemmel L. Validation of a modified Early Warning Score in medical admissions. QJM 2001;94:521–6.
13. Seymour CW, Liu VX, Iwashyna TJ, Brunkhorst FM, Rea TD, Scherag A, et al. Assessment of clinical criteria for sepsis: for the third international consensus definitions for sepsis and septic shock (Sepsis-3). JAMA 2016;315:762–74. [CrossRef]
14. Zhou F, Yu T, Du R, Fan G, Liu Y, Liu Z, et al. Clinical course and risk factors for mortality of adult inpatients with COVID-19 in Wuhan, China: a retrospective cohort study. Lancet. 2020 Mar 28;395(10229):1054-1062. [CrossRef]
15. CDC COVID-19 Response Team. Coronavirus disease 2019 in children - United States, February 12-April 2, 2020. MMWR Morb Mortal Wkly Rep 2020;69:422–6. [CrossRef]
16. Covino M, Sandroni C, Santoro M, Sabia L, Simeoni B, Bocci MG, et al. Predicting intensive care unit admission and death for COVID-19 patients in the emergency department using early warning scores. Resuscitation 2020;156:84–91. [CrossRef]
17. Richardson S, Hirsch JS, Narasimhan M, Crawford JM, McGinn T, Davidson KW, et al. Presenting characteristics, comorbidities, and outcomes among 5700 patients hospitalized with COVID-19 in the New York City area. JAMA 2020;323:2052–9. [CrossRef]
18. Pokeerbux MR, Yelnik CM, Faure E, Drumez E, Bruandet A, Labreuche J, et al; Lille Covid-team. National early warning score to predict intensive care unit transfer and mortality in COVID-19 in a French cohort. Int J Clin Pract 2021;75:e14121. [CrossRef]
19. Wu Z, McGoogan JM. Characteristics of and important lessons from the coronavirus disease 2019 (COVID-19) outbreak in China: summary of a report of 72 314 cases from the Chinese Center for Disease Control and Prevention. JAMA 2020;323:1239–42. [CrossRef]

20. Hu H, Yao N, Qiu Y. Predictive value of 5 early warning scores for critical COVID-19 patients. Disaster Med Public Health Prep 2022;16:232–9. [CrossRef]
21. Wang L, Lv Q, Zhang X, Jiang B, Liu E, Xiao C, et al. The utility of MEWS for predicting the mortality in the elderly adults with COVID-19: a retrospective cohort study with comparison to other predictive clinical scores. PeerJ 2020;8:e10018. [CrossRef]
22. Su Y, Ju MJ, Xie RC, Yu SJ, Zheng JL, Ma GG, et al. Prognostic accuracy of early warning scores for clinical deterioration in patients with COVID-19. Front Med (Lausanne) 2021;7:624255. [CrossRef]
23. Gidari A, De Socio GV, Sabbatini S, Francisci D. Predictive value of National Early Warning Score 2 (NEWS2) for intensive care unit admission in patients with SARS-CoV-2 infection. Infect Dis (Lond) 2020;52:698–704. [CrossRef]
24. Singer M, Shankar-Hari M. qSOFA, Cue Confusion. Ann Intern Med 2018;168:293–5. [CrossRef]
25. Vincent JL, Martin GS, Levy MM. qSOFA does not replace SIRS in the definition of sepsis. Crit Care 2016;20:210. [CrossRef]
26. Heldt S, Neuböck M, Kainzbauer N, Shao G, Tschoellitsch T, Duenser M, et al. qSOFA score poorly predicts critical progression in COVID-19 patients. Wien Med Wochenschr 2022;172:211–9. [CrossRef]
27. Su Y, Tu GW, Ju MJ, Yu SJ, Zheng JL, Ma GG, et al. Comparison of CRB-65 and quick sepsis-related organ failure assessment for predicting the need for intensive respiratory or vasopressor support in patients with COVID-19. J Infect 2020;81:647–79. [CrossRef]
28. Bradley P, Frost F, Tharmaratnam K, Wootton DG; NW Collaborative Organisation for Respiratory Research. Utility of established prognostic scores in COVID-19 hospital admissions: multicentre prospective evaluation of CURB-65, NEWS2 and qSOFA. BMJ Open Respir Res 2020;7:e000729. [CrossRef]
29. Baker KF, Hanrath AT, Schim van der Loeff I, Kay LJ, Back J, Duncan CJ. National Early Warning Score 2 (NEWS2) to identify inpatient COVID-19 deterioration: a retrospective analysis. Clin Med (Lond) 2021;21:84–9. [CrossRef]
30. Salottolo K, Carrick M, Johnson J, Gamber M, Bar-Or D. A retrospective cohort study of the utility of the modified early warning score for interfacility transfer of patients with traumatic injury. BMJ Open 2017;7:e016143. [CrossRef]
31. Myrstad M, Ihle-Hansen H, Tveita AA, Andersen EL, Nygård S, Tveit A, et al. National Early Warning Score 2 (NEWS2) on admission predicts severe disease and in-hospital mortality from Covid-19 - a prospective cohort study. Scand J Trauma Resusc Emerg Med 2020;28:66. [CrossRef]