REUE | Original Article

Evaluation of COVID-19–specific pneumonia severity risk scales for use in Emergency Departments

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OBJECTIVE. To evaluate 2 scales for COVID-19 pneumonia severity and compare them to scales used to assess severity in general and community-acquired pneumonia.

METHODS. Retrospective study of patients diagnosed with pneumonia in the emergency department and who tested positive for COVID-19 between March 1 and April 30, 2020. In addition to recording age and sex, we calculated scores with the 2 specific tools (PREDICOVID and CLINIC) as well as the National Early Warning Score (NEWS), the Quick Sequential Organ Failure Assessment (qSOFA), the Pneumonia Severity Index (PSI), and the CURB 65 score (for confusion, blood urea nitrogen level, respiratory rate, and systolic blood pressure). Outcomes recorded were hospitalization, admission to an intensive care unit (ICU), in-hospital mortality, and 30-day mortality. The area under the receiver operating characteristic curve (AUC) was calculated to assess each score's ability to predict mortality.

RESULTS. We analyzed data for 3499 patients. The mean (SD) age of patients included was 67.9 (17) years; 2660 of the patients (76%) were hospitalized, and 839 (27%) were admitted to the ICU. There were 630 in-hospital deaths (18.4%). Patients with PREDICOVID scores in the first to third quintiles had significantly lower in-hospital mortality (10.8% vs 38.1% in higher quintiles, $P < .001$). Patients with CLINIC scores indicating low to intermediate risk also had significantly lower in-hospital mortality (12.8% vs 85.7%, $P < .001$). The AUC values and 95% CIs for the scales as predictors of mortality were as follows: PSI, 0.69 (0.41-0.96); PREDICOVID, 0.65 (0.30-0.99); CLINIC, 0.63 (0.25-1.00), CURB-65, 0.62 (0.26-0.96); NEWS, 0.58 (0.23-0.94); and qSOFA, 0.38 (0.36-0.73).

CONCLUSIONS. All 6 scales were able to predict mortality. The PSI had the greatest predictive capacity.

Key words: Emergency department. Mortality. Risk scales.

Evaluación de escalas de riesgo de neumonía por COVID-19 en el servicio de urgencias

OBJETIVO. Evaluar dos escalas específicas para la enfermedad por coronavirus (COVID-19) comparándolas con escalas de gravedad global y de neumonía adquirida en la comunidad.

MÉTODOS. Estudio retrospectivo de pacientes diagnosticados en urgencias de neumonía y test positivo para COVID-19 desde el 1 de marzo al 30 de abril de 2020 con las siguientes variables de estudio: edad, sexo, escala PREDICOVID, escala CLINIC, escala NEWS, escala qSOFA y las escalas Fine y CURB 65. Se registró la necesidad de ingreso en la unidad de cuidados intensivos (UCI) y la mortalidad tanto intrahospitalaria como a los 30 días, con cálculo de curvas ROC para mortalidad.

RESULTADOS. Se analizaron 3.494 pacientes, con una edad media de 67,9 ± 17 años. 2.660 (76%) de los pacientes ingresaron en el hospital y 839 (27%) en la UCI del hospital. Fallecieron intrahospitalariamente 630 pacientes (18,4%). Las puntuaciones en la escala PREDICOVID en el 1.er-3.er quintil mostraron una mortalidad menor de forma estadísticamente significativa intrahospitalaria (10,8% *vs* 38,1%; p < 0,001).Puntuaciones en la escala CLINIC de riesgo bajo-intermedio mostraron mortalidad menor de forma estadísticamente significativa (12,8 *vs* 85,7%; p < 0,001). El valor obtenido al analizar la curva ROC para la mortalidad en las distintas escalas fue el siguiente: Escala Fine 0,69 (IC 0,41-0,96), Escala PREDICOVID 0,65 (IC 0,30-0,99), Escala CLINIC 063 (IC 0,25-1,00), Escala CURB-65 0,62 (IC 0,26-0,96), Escaña News 0,58 (IC 0,23-0,94), Escala q-SOFA 0,38 (IC 0,36-0,73).

CONCLUSIONES. El comportamiento de las 6 escalas fue favorable a la hora de predecir la mortalidad, siendo la escala Fine la que presentaba una mejor capacidad predictiva.

Palabras clave: Urgencias. Mortalidad. Escalas.

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Introduction

Coronavirus disease 2019 (COVID-19), caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), was one of the most important causes of morbidity and mortality in 2020[1] and continues to be a major problem for health systems, despite the time elapsed since its onset.

It is the responsibility of emergency departments (EDs) to adequately differentiate those patients affected by COVID-19 who present with a more severe prognosis and for whom early and accurate management is essential.[2] Therefore, SEMES has created a specific research group dedicated to COVID-19, the SIESTA network.[3] Recently, several studies have been published on risk stratification and management of these patients.[4-6]

Regarding the use of prediction scales in this disease, several protocols have proposed the use of "traditional" scales for the evaluation of community-acquired pneumonia, such as CURB-65 and the Fine Scale, as well as general severity scales designed to detect early clinical deterioration in hospitalized patients, such as the NEWS scale and the quick SOFA score. However, their usefulness in COVID-19 has been little studied.[7-11] COVID-19 has posed a challenge in this regard, as we faced an unknown disease in which patient progression was uncertain, and the scales used during the first wave to classify severity were not known to provide information adequately aligned with patient prognosis.[12] Given the different clinical course of COVID-19 infection vs other infections, new scales have been described to discriminate the clinical trajectory of this disease. In this regard, of particular interest is the model developed at *Hospital Clínic de Barcelona* (Catalonia, Spain) to predict disease severity in COVID-19 patients,[13] as well as the PREDICOVID scale, developed at *Hospital Clínico San Carlos* (Madrid, Spain), which allows risk stratification for 30-day mortality in patients treated for COVID-19.[14] When assessing the severity of patients with COVID-19 pneumonia, few publications compare different scales.[15,16]

In conclusion, multicenter studies are lacking to demonstrate the validity of the scales in patients with pneumonia and COVID-19, and none can be recommended for generalized use.[17,18] In addition, due to the scarcity of studies, uncertainties remain regarding the applicability of new scales and how they compare with more validated tools in this complex scenario of COVID-19 infection.

The aim of the study was to compare scales traditionally used with newly designed COVID-19-specific scales. To this end, a multicenter cohort of patients treated in the EDs of Spanish hospitals with a diagnosis of COVID-19 pneumonia was used to compare the different scales against in-hospital mortality.

Method

We conducted a retrospective, observational, non-interventional, multicenter cohort study. The study period corresponded to the first wave of the COVID-19 pandemic (March 1st through April 30th, 2020). Data were collected from patients with radiologically documented pneumonia and PCR-confirmed (polymerase chain reaction) COVID-19 infection who were treated in the EDs of the participating hospitals. Investigators at each center obtained data from a clinical registry of patients meeting inclusion criteria. The hospitals included in the study are listed in Table 1.

Study variables included epidemiological data (age, sex), vital signs upon arrival (blood pressure, heart rate, oxygen saturation, respiratory rate, level of consciousness), comorbidities (presence of cancer, heart failure, renal failure), and laboratory variables (lymphocytes, D-dimer). Based on these data, results were calculated for the NEWS, QSOFA, CLINIC, PREDICOVID, CURB-65, and FINE scales. A description of the scales used is shown in Table 2.[14,17-20] Regarding the use of the scales in the study, the authors decided to include only patients from *Hospital Clínic* and *Hospital San Carlos* when analyzing these new scales to avoid bias, while the rest of the scales were applied in all hospitals. The cutoff points chosen for poor prognosis were as follows: QSOFA ≥ 2 (14% increase in mortality), PREDICOVID quintiles 4–5 (30-day mortality rate > 21%), CURB-65 ≥ 3 (mortality rate > 17%), FINE IV–V (mortality > 8%), NEWS > 6 points (high clinical risk, 30% mortality), and CLINIC scale ≥ 7 points (30-day mortality rate, 67%).[14,17-20]

For D-dimer, a dichotomous variable was used, with values below or above 1,000 ng/mL. Lymphocyte count was also dichotomized as below or above 1,000/µL.

Outcome variables were in-hospital mortality and 30-day mortality.

Qualitative variables were expressed as number and percentage with their 95% confidence interval (95% CI), and quantitative variables as mean and standard deviation or median and interquartile range in cases of asymmetry. Sensitivity, specificity, and predictive power of the different scales were calculated. To determine which of the analyzed scales had the best discriminatory power for mortality, ROC curve analysis and the area under the curve were used. Differences were considered statistically significant when $P < .05$.

Data were analyzed using SPSS© version 24.

Table 1. List of participating hospitals and number of patients recruited for the study

Hospital	Patients
Hospital Marqués de Valdecilla	211
Hospital Dr. Peset Valencia	17
Hospital Alicante	33
Hospital Universitario de Málaga	105
Hospital del Mar	200
Hospital Santa Tecla	47
Hospital Terrasa	451
Hospital Burgos	197
Hospital Arnau Villanova	34
Hospital Clínic Barcelona	661
Hospital Universitario Zaragoza	393
Hospital Valle de los Pedroches	14
Hospital de Soria	118
Hospital de Vic	447
Clínica Universitaria Navarra	101
Hospital Clínico San Carlos	469

Table 2. Scales used in the study

	Year	Variables	High risk
FINE	1997	Age, sex, residence, neoplasia, heart failure, stroke, renal failure, liver failure, altered mental status, temperature, heart rate, systolic blood pressure, respiratory rate, pH, sodium, glucose, hematocrit, PaO_2, SaO_2, pleural effusion.	Grade IV-V
CURB65	2003	Confusion, urea, respiratory rate, blood pressure, age ≥ 65 years.	≥ 3 points
NEWS	2012	Respiratory rate, oxygen saturation, temperature, SBP, heart rate, level of consciousness.	≥ 6 points
QSOFA	2016	SBP < 100, respiratory rate > 22, and altered mental status.	≥ 2 points
CLINIC	2020	Age > 50 years, Barthel Index < 90, altered level of consciousness, SaO_2/FiO_2 index < 400, abnormal lung auscultation, platelets < 100,000/mm^3 CRP > 5 mg/dL, and glomerular filtration rate < 45 mL/min.	≥ 7 points
PREDICOVID	2020	Age, oxygen saturation, glomerular filtration rate, tissue injury via LDH, C-reactive protein, platelet count, and presence of dementia.	4^{th}–5^{th} quintile

SBP: systolic blood pressure.

This study was conducted in full compliance with the principles outlined in the Declaration of Helsinki. The project, a substudy of the SIESTA network, was approved by Hospital Clínic de Barcelona Ethics Committee, code HCB/2020/0534.

Results

A total of 3,499 patients were included. The distribution of patients by hospital is shown in Table 1. A general description of the study variables is shown in Table 2. The patients' mean age was 64.48 ± 16 years; 2,064 (59%) were men and 1,435 (41%) women. A total of 2,519 (72%) cases exhibited bilateral pneumonia on the initial chest X-ray upon admission. Regarding clinical course, 2,659 (76%) patients were hospitalized and 944 (27%) required admission to the intensive care unit (ICU). A total of 643 (18.4%) patients died during hospitalization, and the 30-day mortality rate was 26.1% (913 patients).

Regarding the comparison of laboratory findings with ICU admission and mortality, univariate analysis showed that patients with lymphocyte counts < 1,000/µL had a higher risk of ICU admission (31% vs 23%; $P < .001$), in-hospital mortality (23.9% vs 11.9%; $P < .001$), and 30-day mortality (28.6% vs 23.7%; $P = .006$). With respect to D-dimer, patients with D-dimer levels > 1,000 ng/mL had a higher risk of ICU admission (32.7% vs 23.8%; $P < .001$), in-hospital mortality (31% vs 10.8%; $P < .001$), and 30-day mortality (33% vs 20.4%; $P < .001$).

The description of the calculation of results for each risk scale[23-26] is shown in Table 3.

The number of patients included in each scale, including missing values, was: CLINIC Scale: 498 (158 missing). PREDICOVID Scale: 469 (0 missing), NEWS Scale: 1,032 patients (2,467 missing), QSOFA Scale: 2,547 patients (952 missing), CURB-65 Scale: 1,756 patients (1,743 missing), and MFINE Scale: 1,229 patients (2,200 missing).

The results of the scales according to mortality are shown in Table 4.

Patients with NEWS scores ≤ 6 showed significant differences in ICU admission (7.4% vs 28.8%; $P < .001$) and demonstrated lower mortality both in-hospital (8.9% vs 35.1%; $P < .001$) and at 30 days (7.8% vs 29.0%; $P < .001$).

Patients with QSOFA scores 0–1 showed differences in ICU admission (12.0% vs 31.5%; $P < .001$) and demonstrated lower in-hospital mortality (13.3% vs 43.3%; $P < .001$) and 30-day mortality (11.8% vs 50.8%; $P < .001$) vs scores 2–3.

Cases with CURB-65 scores 0–2 demonstrated lower in-hospital mortality (10.1% vs 43.3%; $P < .001$) and 30-day mortality (12.5% vs 39.8%; $P < .001$) vs scores 3–4.

Finally, FINE scores 1–3 showed lower in-hospital mortality (6.6% vs 31.6%; $P < .001$) and 30-day mortality (12.5% vs 39.8%; $P < .001$) vs scores 4–5.

With respect to COVID-19–specific scales, patients with PREDICOVID scores in the 1st–3rd quintiles demonstrated lower in-hospital mortality (15.1% vs 20.4%; $P < .001$) and 30-day mortality (23.7% vs 35%; $P < .001$) vs those in the 4^{th}–5^{th} quintiles.

Similarly, cases with CLINIC scale scores in the low-intermediate risk category showed lower in-hospital mortality (12.8% vs 77.8%; $P < .001$) vs high-risk scores.

Table 3. General description of the variables analyzed in the study

Patients included in the study: 3,499	**Mean ± SD** n (%)
Demographic data	
Mean age	64.48 ± 16 years
Male sex	2.064 (59)
Comorbidities	
Neoplasia	82 (2.2)
Heart failure	70 (1.9)
Renal failure	131 (3.5)
Symptoms in the emergency department	
Mean SBP	129 ± 23
SBP < 100 mmHg	293 (8.4)
Heart rate	89 ± 17
Respiratory rate > 22	933 (25.4)
Oxygen saturation	92 ± 6
Decreased level of consciousness	890 (24)
Laboratory data	
D-dimer > 1,000 ng/mL	839 (24)
Lymphocytes < 1,000/µL	1,784 (51)
Radiological presentation	
Bilateral pneumonia	2,519 (72)
Scales	
NEWS > 6 points	205 (19.9)
qSOFA ≥ 2 points	348 (13.7)
CURB-65 ≥ 3 points	358 (20.4)
FINE IV–V	457 (37.2)
PREDICOVID 4^{th}–5^{th} quintile	173 (37)
CLINIC ≥ 7 points	9 (1.7)
Clinical outcomes	
Hospitalized patients	2,659 (76)
ICU admissions	944 (27)
In-hospital mortality	643 (18.4)
30-day mortality	913 (26.1)

SBP: systolic blood pressure; ICU: intensive care unit.

Table 4. Summary of statistical values of the scales analyzed in relation to risk group and in-hospital mortality

	Non–high-risk group n (%)	Mortality n (%)	High-risk group n (%)	Mortality n (%)	Chi-square test
Escala NEWS	824 (80.1)	73 (8.9)	205 (19.9)	72 (35.1)	0.0001
Escala qSOFA	2,154 (86.2)	286 (13.3)	344 (13.8)	149 (43.3)	0.0001
Escala CURB65	1,350 (79.1)	136 (10.1)	356 (20.9)	154 (43.3)	0.0001
Escala FINE	743 (62.0)	49 (6.6)	456 (38)	144 (31.6)	0.0001
Escala PREDICOVID	263 (56.0)	39 (15.1)	206 (44.0)	95 (20.4)	0.0001
Escala CLINIC	508 (98.3)	65 (12.8)	9 (1.7)	7 (77.8)	0.0001

The results of the ROC curves are shown in Figure 1. The FINE scale had the highest discriminatory power for mortality, with an area under the curve (confidence interval) of 0.688 (0.41–0.96).

Discussion

The first wave of COVID-19 infection had a very significant impact on the EDs of Spanish hospitals. Despite the availability of clinical prediction scales, there was no homogeneous use of these tools during the pandemic.

This study evaluates the ability of 6 risk scales to predict in-hospital mortality in COVID-19 patients treated in Spanish hospital EDs during the first wave of the pandemic. The main findings show that the FINE scale is the prognostic tool among those studied that best predicts the risk of poor clinical outcomes.

In this work, we compared the newly developed scales created during the pandemic at *Hospital Clínic* and *Hospital San Carlos* with those most widely used in daily clinical practice, such as the FINE and the CURB-65 scales, and with scales used in sepsis patients such as the NEWS and the qSOFA. We believe this article contributes to a better understanding of clinical prediction scales for severe COVID-19 infection in Spanish hospitals. To our knowledge, this is the study with the largest number of included patients evaluating clinical prediction scales for COVID-19 pneumonia in Spanish EDs. The mortality rate observed in this study was high (18%), although comparable to another multicenter study conducted in Spanish hospitals (20.9%).[21]

First, regarding traditional pneumonia prognostic scales, in the study by Satici[9] the FINE scale in group 4 showed better sensitivity (80% vs 73%) and specificity (89% vs 85%), but a similar negative predictive value (98% vs 97%) for predicting death vs a CURB-65 score of 2. In our series, the prognostic capacity for mortality in both scales was similar, with FINE demonstrating better discrimination—findings consistent with those reported by Raúl López in his study.[5] In this regard, FINE and CURB-65 scores showed sensitivity and specificity values similar to those found in other studies on community-acquired pneumonia.[7,9,22] The superior discriminatory capacity of the FINE scale was expected, since it incorporates several parameters—such as age, comorbidities, and hypoxemia—which have been associated with a higher risk of mortality.

When analyzing global severity scales used in sepsis patients, qSOFA showed lower sensitivity than FINE and CURB-65 (AUROC 0.40 vs 0.69 and 0.71, $P < .001$ for both comparisons). These results were in line with those reported by Artero and Su.[21,22] qSOFA was the only scale that adequately discriminated ICU admission, similar to its performance in studies conducted outside the COVID-19 epidemic.[22] Despite its lower sensitivity, qSOFA has the advantage of not requiring laboratory test results. The results of the NEWS scale were also favorable, although with an area under the curve lower than that reported by Lalueza *et al*.[23] It is possible that the older age of the sample and therapeutic limitations applied to certain patients influenced these results in comparison to other scales.

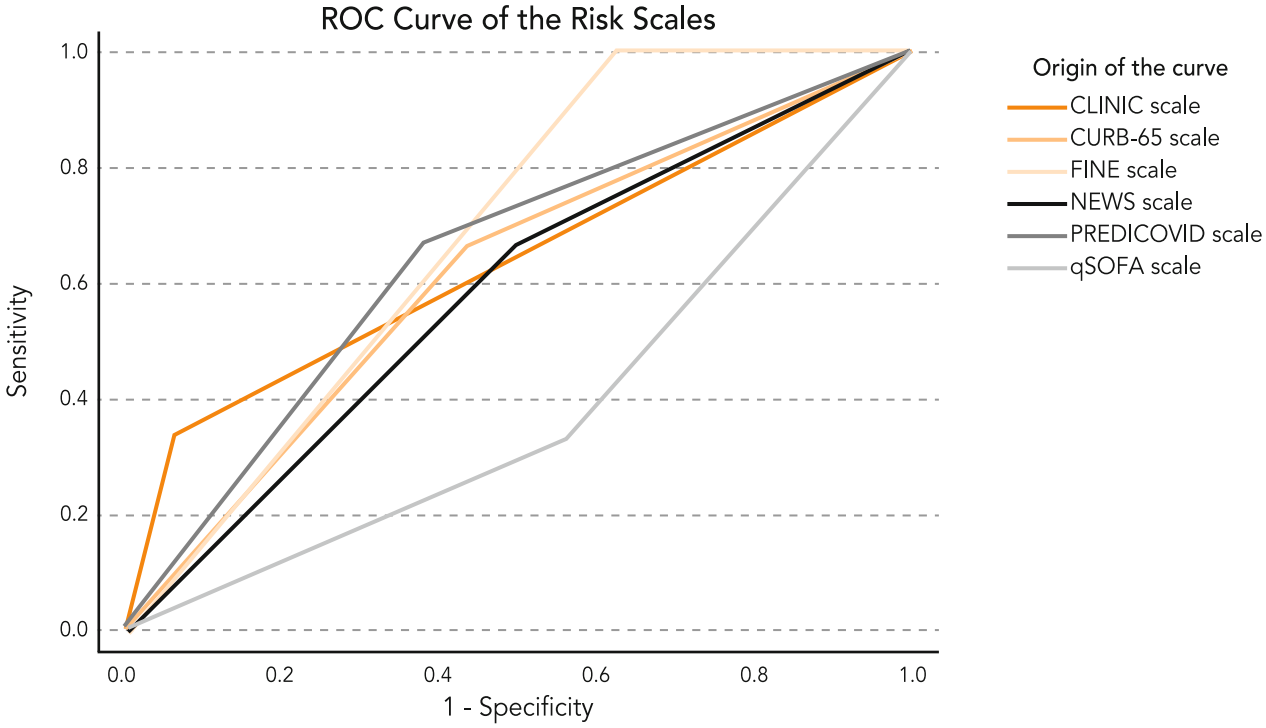
When analyzing the new COVID-19–specific scales, the PREDICOVID scale performed adequately in discriminating mortality, similar to the other scales analyzed, but its area under the curve was lower than that of FINE. The same occurred with the CLINIC scale, although this tool showed the highest mortality when comparing high-risk versus low-to-intermediate-risk groups. It should be noted that both scales were designed to predict severity in patients with COVID-19 infection, but not specifically in the subgroup analyzed in this study—patients with pneumonia and COVID-19 who required hospital admission in most cases.

Furthermore, we performed, although not as a primary aim, an evaluation of key laboratory markers involved in COVID-19 prognosis, such as lymphopenia and D-dimer, as reported in several publications.[24,25] Both markers showed favorable prognostic associations in our analysis.

As limitations of our study, we highlight its retrospective design, which led to missing data, as well as the post-hoc calculation of the scales. We tried to limit bias in the analysis of the new scales by including only patients treated in the hospitals where the scales were originally developed. The advanced age of the patients may also limit the interpretation of results related to ICU admission.

We believe these new scales should be evaluated in large, ideally prospective and multicenter studies to demonstrate their prognostic effectiveness and potential use in COVID-19 patients, which may aid initial care in EDs. New scales may add valuable information for clinicians, but perhaps should be redefined to improve mortality prediction. Moreover, they could serve as complementary tools alongside analytical data such as D-dimer and lymphocyte count, improving the emergency clinician's decision-making process.[16]

In conclusion, clinical prediction scales may assist emergency physicians in managing patients with pneumonia and COVID-19. In our study, the FINE scale showed the best performance for predicting mortality.



ROC Curve Area

Test Variable	Area	Std. Error[a]	Asymptotic Sig.[b]	95% Asymptotic CI	
				Lower Limit	Upper Limit
CLINIC scale	.635	.170	.425	.303	.968
NEWS scale	.583	.179	.641	.233	.934
PREDICOVID scale	.646	.178	.413	.297	.995
qSOFA scale	.385	.179	.521	.035	.735
CURB-65 scale	.615	.179	.521	.265	.965
FINE scale	.688	.063	.003	.565	.810
FINE scale					

[a]Under the nonparametric assumption.
[b]Null hypothesis: true area = 0.5.

Classifier evaluation metrics

Test Variable	Gini Index	K-S Statistics	
		Max K-S[a]	Cutoff[b]
CLINIC scale	.635	.170	.425
NEWS scale	.583	.179	.641
PREDICOVID scale	.646	.178	.413
qSOFA scale	.385	.179	.521
CURB-65 scale	.615	.179	.521
FINE scale	.688	.063	.003
FINE scale			

[a]Maximum Kolmogorov–Smirnov (K-S) metric.
[b]If several cutoff values correspond to the maximum K-S, the highest value is reported.

Difference in paired-sample ROC curve areas

Test Result Pair	Asymptotic		AUC difference	Std. error of difference[b]	95% Asymptotic CI	
	Area	Sig. (Two-tailed)[a]			Lower limit	Upper limit
CLINIC scale – NEWS scale	.292	.771	.052	.565	–.298	.402
CLINIC scale – PREDICOVID scale	–.031	.975	–.010	.634	–.674	.653
CLINIC scale – qSOFA scale	.835	.404	.250	.614	–.337	.837
CLINIC scale – CURB-65 scale	.117	.907	.021	.565	–.328	.370
CLINIC scale – FINE scale	–.283	.777	–.052	.483	–.413	.309
NEWS scale – PREDICOVID scale	–.207	.836	–.062	.620	–.655	.530
NEWS scale – qSOFA scale	.556	.578	.198	.648	–.500	.895
NEWS scale – CURB-65 scale	–1.000	.317	–.031	.543	–.092	.030
NEWS scale – FINE scale	–.585	.558	–.104	.487	–.453	.245
PREDICOVID scale – qSOFA scale	1.362	.173	.260	.574	–.114	.635
PREDICOVID scale – CURB-65 scale	.104	.917	.031	.619	–.559	.621
PREDICOVID scale – FINE scale	–.216	.829	–.042	.492	–.419	.336
qSOFA scale – CURB-65 scale	–.642	.521	–.229	.649	–.929	.471
qSOFA scale – FINE scale	–1.526	.127	–.302	.494	–.690	.086
CURB-65 scale – FINE scale	–.405	.685	–.073	.488	–.426	.280

[a]Null hypothesis: true area difference = 0.
[b]Under the nonparametric assumption.

Figure 1. ROC curve analysis results.

ARTICLE INFORMATION

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