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ORIGINAL RESEARCH

Performance of the CURB-65, SOFA, NEWS2, and 4C Mortality Score scales to predict in-hospital mortality from COVID-19 within the first 30 days in Lima, Peru

Capacidad de las escalas CURB-65, SOFA, NEWS2 y 4C para predecir la mortalidad hospitalaria por COVID-19 en los primeros 30 días en Lima, Perú

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Abstract

Introduction: Although the COVID-19 pandemic has been contained, new and fatal variants causing a high inflammatory response could emerge. Therefore, the use of instruments that allow healthcare workers to identify potentially severe patients is relevant.
Objective: To determine the performance of the CURB-65, SOFA, NEWS2, and 4C Mortality Score scales in predicting in-hospital mortality due to COVID-19 within the first 30 days in Lima, Peru.
Materials and methods: Retrospective analytical study conducted in 268 adults with COVID-19 pneumonia hospitalized between January 1 and June 30, 2021, in a tertiary care hospital in Lima, Peru. To determine the prediction performance of in-hospital mortality within the first 30 days due to COVID-19, the ROC (receiver operating characteristic) curves and areas under the curve (AUC) of each scale were calculated, as well as their sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV). The score cut-off points were obtained using the Youden index.
Results: The median age of the participants was 54 years (IQR: 45.20-64.00), 177 (66.04%) were male, and 67 (25.00%) died. The score with the highest AUC was the 4C Mortality Score (0.89; 95%CI: 0.84-0.93), followed by the SOFA (0.87; 95%CI: 0.83-0.92).
Conclusions: All four scales had an acceptable predictive performance for in-hospital mortality in patients with COVID-19, and the 4C Mortality Score had the best performance, followed by the SOFA.

Resumen

Introducción. A pesar de que la pandemia por COVID-19 ha sido controlada, podrían surgir nuevas y fatales variantes que generen una respuesta inflamatoria alta. Por tanto, resulta pertinente el uso de instrumentos que permitan al personal sanitario identificar pacientes potencialmente graves.
Objetivo. Determinar la capacidad de las escalas CURB-65, SOFA, NEWS2 y 4C Mortality Score para predecir la mortalidad hospitalaria por COVID-19 en los primeros 30 días en Lima, Perú.
Materiales y métodos. Estudio analítico retrospectivo realizado en 268 adultos con neumonía por COVID-19 hospitalizados entre enero 1 y junio 30 del 2021 en un hospital de tercer nivel de atención en Lima, Perú. Para determinar el rendimiento de predicción de mortalidad hospitalaria por COVID-19 dentro de los primeros 30 días, se calcularon las curvas ROC (Operativa del receptor) y las áreas bajo la curva (AUC) de cada escala, así como su sensibilidad, especificidad, valor predictivo positivo (VPP) y valor predictivo negativo (VPN). Los puntos de corte de puntaje de las escalas se obtuvieron mediante el índice de Youden.
Resultados. La mediana de edad de los participantes fue de 54 años (RIQ: 45.20-64.00), 177 (66.04%) eran hombres y 67 (25.00%) fallecieron. La escala con el mayor AUC fue la 4C Mortality Score (0.89; IC95%: 0.84-0.93), seguida de la SOFA (0.87; IC95%: 0.83-0.92).
Conclusiones. Las cuatro escalas tuvieron una aceptable capacidad predictiva de mortalidad hospitalaria en pacientes con COVID-19, siendo la 4C Mortality Score la que tuvo el mejor rendimiento, seguida de la SOFA.

Introduction

The World Health Organization declared COVID-19 a pandemic on March 11, 2020, and since then it has urged all countries of the world to take measures to contain its spread.[1] As of 2023, this disease is still considered a public health issue due to an increase, not only in medical information about it, but also in cumulative infections and deaths.[2] In Peru, by August 28, 2023, a total of 4 519 595 confirmed cases of COVID-19 and 221 089 deaths related to this disease had been officially reported.[3]

Developing countries such as Peru have limited infrastructure and medical resources, so measures such as rapid, accurate and early assessment of potentially critical patients are very relevant.[4] Accordingly, several instruments have been used for the identification and timely care of patients at increased risk of mortality, such as the CURB-65, the Sequential Organ Failure Assessment (SOFA), and the National Early Warning Score 2 (NEWS2). It should be noted that while these scales are not specific for patients with COVID-19, they have parameters that may be of interest to this population during their hospitalization.[5-11]

Other instruments have also been designed to evaluate patients with COVID-19, such as the 4C Mortality Score (Coronavirus Clinical Characterisation Consortium Mortality Score), which has proven to be useful in clinical decision making and can be used to stratify patients requiring hospitalization into different treatment groups.[1] In Peru, it has been recommended by the Seguro Social de Salud (Social Health Insurance) to identify patients at high risk of mortality and worsening on hospital admission due to COVID-19.[12]

Even though these are promising instruments, evidence of their use and effectiveness in Latin American countries such as Peru is still scarce. Therefore, the objective of the present study was to determine the performance of the CURB-65, SOFA, NEWS2 and 4C Mortality Score scales in predicting in-hospital mortality due to COVID-19 within the first 30 days in Lima, Peru.

Materials and methods

Study type

Retrospective analytical study.

Study population and sample

The study population consisted of all adult patients (>18 years) with a diagnosis of COVID-19 pneumonia confirmed by imaging tests, clinical manifestations, and laboratory tests (molecular, antigen, and serological tests, depending on the availability of hospital resources) who were hospitalized for at least 30 days between January 1 and June 30, 2021, in the Internal Medicine Department of the Hospital Nacional Dos de Mayo (tertiary care level) in Lima, Peru (N=2 790). Sample size was calculated using the Epidat version 4.1 software with a statistical power of 80% and a confidence level of 95%, obtaining a sample size of 268 patients, who were selected by simple random sampling.

Procedures and variables

The outcome variable was hospital mortality, defined as death due specifically to COVID-19 within 30 days of hospitalization. Exposure variables included the scores

obtained from the CURB-65, SOFA, NEWS2 and 4C scales, which were determined using data recorded upon hospital admission. It should be noted that data on bilirubin levels were not available for 28 participants, so it was not possible to determine their score on the SOFA scale.

Regarding score analysis, the following cut-off points were established using the Youden index (YI): CURB-65: <2 and ≥2; SOFA: <4 and ≥4; NEWS2 <9 and ≥9; and 4C Mortality Score: <10 and ≥10.

Finally, data on the following variables were collected: age, sex, COVID-19 diagnostic test (molecular, antigen, or serological; the latter was considered due to limited resources) and duration of hospitalization. Other variables assessed at hospital admission were also collected, such as vital signs (heart rate, respiratory rate, temperature, and systolic, diastolic and mean blood pressure); signs and symptoms; state of consciousness as per neurological examination and Glasgow Coma Scale score (altered level of consciousness defined as a score <15 plus clinical signs); oxygen saturation; supplemental oxygen requirement; presence of co-morbidities; and results of the following laboratory tests: blood urea nitrogen test, arterial blood gases (arterial oxygen pressure/fraction of inspired oxygen [PaO_2/FiO_2] ratio), platelet count, blood bilirubin test, creatinine test, and C-reactive protein (CRP) test.

All these data were collected through a systematic review of the medical records of hospitalized patients from a list provided by the hospital's statistics office. The data were then entered and organized in a spreadsheet created in Microsoft Excel for subsequent analysis.

Statistical analysis

Data were analyzed in the STATA software (version 17). Clinical and laboratory findings were described using absolute frequencies and percentages for categorical variables and means and standard deviations or medians and interquartile ranges for quantitative variables according to the distribution of the data (Kolmogorov-Smirnov test). The optimal cut-off point for each scale was calculated using the YI, while the distribution of scores for each scale was determined based on those cut-off points depending on the patient mortality outcome (deceased vs. survivors).

To determine the performance of the four scales in predicting in-hospital mortality from COVID-19 within the first 30 days, receiver operating characteristic (ROC) curves and their respective areas under the curve (AUC) were calculated, with 95% confidence intervals (95%CI). Also, based on the cut-off point previously established by the YI, the sensitivity, specificity, positive predictive value (PPV) and negative predictive value (NPV) for each scale were calculated using a tetrachoric table.

Ethical considerations

The study followed the ethical principles for biomedical research involving human subjects established in the Declaration of Helsinki[13] and the scientific, technical and administrative standards for health research of Resolution 8430 of 1993 of the Colombian Ministry of Health.[14] It was also approved by the research ethics committees of the Faculty of Medicine of the Universidad Ricardo Palma (Committee Code PG 202 issued on December 23, 2021) and the Hospital Nacional Dos de Mayo (minutes No. 0209-201 DF-HNDM of November 24, 2021).

Results

There were 268 patients, of whom 177 (66.04%) were men and 67 (25%) died. The median age was 54 years (IQR: 45.23-64) and the median length of hospital stay was 8 days (IQR: 4-14). The most common comorbidity was hypertension (22.45%), followed by diabetes mellitus (17.91%) (Table 1).

Regarding the main findings of laboratory tests, it was found that the median PaO2/FiO2 ratio was higher in the survivors group (219mmHg; IQR: 132.56-317.28) than in the deceased group (65mmHg; IQR: 51.72-94.25). In contrast, the median CRP level was higher in patients who died (237.42mg/DL; IQR: 187.52-332.15) than in survivors (75.27mg/DL; IQR: 43.25-203.89) (Table 2).

Table 1. Demographic and clinical characteristics of the sample.

General and clinical characteristics		All patients (n=268)	Survivors (n=201)	Deceased (n=67)
Age in years *		54 (45.23-64)	51 (41-59.52)	65 (57-72)
Sex †	Male	177 (66.04%)	128 (63.71%)	49 (73.12%)
	Female	91 (33.96%)	73 (36.29%)	18 (26.88%)
Length of hospital stay (days) *		8 (4-14)	9 (5-15)	4 (2-9)
Vital signs *	Heart rate	86 (74-96)	80 (72-90)	100 (87-112)
	Respiratory rate	25 (22-29)	24 (21.55-27)	30 (26-32)
	Temperature (°C)	36.8 (36.51-37)	36.7 (36.48-37)	37 (36.82-37)
	Systolic blood pressure	120 (110-130)	120 (110-130)	126 (110-140)
	Diastolic blood pressure	71.5 (68.29-80)	71 (68-80)	72 (70-82)
	Mean arterial pressure	89 (83-96)	88 (82.52-95.53)	92 (83-103)
State of consciousness †	Preserved	252 (94%)	198 (98.47%)	54 (80.60%)
	Altered	16 (6%)	3 (1.53%)	13 (19.40%)
Glasgow Coma Scale *		15 (15-15)	15 (15-15)	15 (15-15)
Symptoms †	Respiratory distress	252 (94%)	185 (92%)	67 (100%)
	General malaise	208 (77.62%)	159 (79.15%)	49 (73.11%)
	Cough	206 (76.94%)	151 (75.13%)	55 (82.17%)
	Fever	106 (39.62%)	76 (37.86%)	30 (44.82%)
	Sensation of increased heat	98 (36.65%)	71 (35.34%)	27 (40.37%)
	Sore throat	94 (35.29%)	78 (39%)	16 (23.94%)
	Headache	84 (31.32%)	67 (33.32%)	17 (25.75%)
	Diarrhea	56 (21%)	46 (22.97%)	10 (15.21%)
	Muscle pain	45 (16.83%)	35 (17.41%)	10 (14.93%)
	Chest pain	44 (16.49%)	33 (16.45%)	11 (16.48%)
	Chills	40 (14.94%)	33 (16.45%)	7 (10.42%)
	Nasal congestion	32 (11.92%)	24 (11.94%)	8 (11.96%)
	Poor sense of smell	24 (9%)	22 (10.91%)	2 (3%)
	Joint pain	23 (8.63%)	21 (10.44%)	2 (3%)
	Abdominal pain	19 (7.15%)	13 (6.52%)	6 (9%)
	Nausea and/or vomiting	14 (5.22%)	11 (5.59%)	3 (4.53%)
	Taste impairment	12 (4.51%)	10 (5%)	2 (3%)
	Decreased appetite	12 (4.56%)	8 (4%)	4 (6%)
	Fatigue	7 (2.62%)	3 (1.53%)	4 (6%)
	Decreased consciousness	6 (2.21%)	3 (1.55%)	3 (4.57%)
	Coughing up blood	6 (2.28%)	0 (0%)	6 (3%)
	Sweating	3 (1.15%)	2 (1%)	1 (1.57%)

General and clinical characteristics		All patients (n=268)	Survivors (n=201)	Deceased (n=67)
O2 saturation *		90 (84-92)	90 (88-93)	80 (70-86)
Supplemental O2 required †		251 (93.72%)	184 (91.55%)	67 (100%)
Comorbidities †	No	149 (55.58 %)	126 (62.70%)	23 (34.30%)
	Yes	119 (44.42%)	75 (37.30%)	44 (65.70%)
Types of comorbidities †,‡	Arterial hypertension	60 (22.45%)	37 (18.42%)	23 (34.32%)
	Diabetes mellitus	48 (17.91%)	30 (14.93%)	18 (26.85%)
	Obesity	25 (9.32%)	18 (9%)	7 (10.47%)
	Neurodegenerative disorders	9 (3.45%)	3 (1.57%)	6 (9%)
	Chronic kidney disease	7 (2.64%)	5 (2.55%)	2 (3%)
	Chronic obstructive pulmonary disease	5 (1.93%)	4 (2%)	1 (1.52%)
	Mild or severe liver disease	5 (1.93%)	4 (2%)	1 (1.52%)
	HIV/AIDS	3 (1.16 %)	2 (1%)	1 (1.52%)
	Cancer	2 (0.78%)	1 (0.55%)	1 (1.52%)

HIV/AIDS: Human immunodeficiency virus / acquired immunodeficiency syndrome.
* Values expressed as: mean (IQR).
† Values expressed as: n (%).
‡ Patients may present more than one comorbidity.

Table 2. Laboratory test findings in a sample of COVID-19 patients.

Laboratory tests		All patients (n=268)	Survivors (n=201)	Deceased (n=67)
COVID-19 screening test †	Serological	11 (4.11%)	7 (3.48%)	4 (5.97%)
	Antigen	161 (60.07%)	115 (57.21%)	46 (68.66%)
	Molecular	96 (35.82%)	79 (39.31%)	17 (25.37%)
Blood urea nitrogen test (mg/dL) *		32.72 (25.55-42.23)	31.86 (24.58-37.92)	41.24 (29.48-58.72)
PaO2/FiO2 ratio (mmHg) *		171 (85-280)	219 (132.56-317.28)	65 (51.72-94.25)
Platelet count (cellx10³/µL) *		279 000 (211 750-367 500)	280 000 (210 000-310 000)	275 000 (217 000-407 000)
Bilirubin test (mg/dL) *		0.64 (0.42-0.83)	0.65 (0.41-0.79)	0.67 (0.45-1.13)
Creatinine test (mg/dL) *		0.63 (0.51-0.82)	0.64 (0.57-0.83)	0.66 (0.52-0.87)
C-reactive protein test (mg/L) *		145.9 (50.33-235.95)	75.27 (43.25-203.89)	237.42 (187.52-332.15)

PaO2/FiO2: arterial oxygen pressure/ fraction of inspired oxygen ratio; CRP: C-reactive protein.
* Values expressed as: median (IQR).
† Values expressed as: n (%).

The cut-off points established for each scale and their application are presented in Table 3 for each patient group (deceased vs. survivors). In the case of the patients who died (n=67), all patients scored ≥4 on the 4C Mortality Score, while 52 scored ≥3 on the SOFA, 65 scored ≥7 on the NEWS-2, and 58 scored ≥2 on the CURB-65 (Table 3).

Regarding the analysis of the ROC curves and the AUC of the scales' performance for predicting in-hospital mortality due to COVID-19, it was found that the scale with the highest AUC was the 4C Mortality Score (0.89; 95%CI: 0.85-0.93) with a cut-off value of 4, a sensitivity of 99.90% (95%CI: 94.6-100.0), and a specificity of 15.40% (95%CI: 10.70-21.20), followed by the SOFA scale (0.87; 95%CI: 0.83-0.92) with a cut-off value of 3, a sensitivity of 98.10% (95%CI: 89.90-99.90) and a specificity of 48.10% (95%CI: 40.80-55.50) (Table 4 and Figure 1).

Table 3. Scores on mortality scales for deceased and survivor groups in a sample of COVID-19 patients.

Scale	Cut-off points	Condition on discharge		
		Deceased	Survivor	Total
4C Mortality Score	Score <4	0	31	31
	Score ≥4	67	170	237
	Total	67	201	268
SOFA	Score <3	1	90	91
	Score ≥3	52	97	149
	Total	53	187	240
NEWS2	Score <7	2	69	71
	Score ≥7	65	132	197
	Total	67	201	268
CURB-65	Score <2	9	132	141
	Score ≥2	58	69	127
	Total	67	201	268

Table 4. Predictive performance of the 4C Mortality Score, SOFA, CURB-65 and NEWS2 scales in a sample of patients with COVID-19.

Scale	Area under the curve (95%CI)	Cut-off point	Sensitivity % (95%CI)	Specificity % (95%CI)	Positive predictive value % (95%CI)	Negative predictive value % (95%CI)	Youden Index
4C Mortality Score	0.89 (0.85-0.93)	4	99.90 (94.6-100.0)	15.40 (10.7-21.2)	28.30 (27.1-29.5)	99.90 (96.6-100.0)	0.305
SOFA	0.87 (0.83-0.92)	3	98.10 (89.9-99.9)	48.10 (40.8-55.5)	34.90 (31.7-38.2)	98.90 (92.8-99.8)	0.265
CURB-65	0.82 (0.76-0.88)	2	86.60 (76.0-93.7)	65.70 (58.7-72.2)	45.70 (40.5-51.0)	93.60 (88.8-96.5)	0.140
NEWS2	0.80 (0.74-0.85)	7	97.00 (89.6-99.6)	34.30 (27.8-41.3)	33.00 (30.6-35.4)	97.20 (89.7-99.3)	0.185

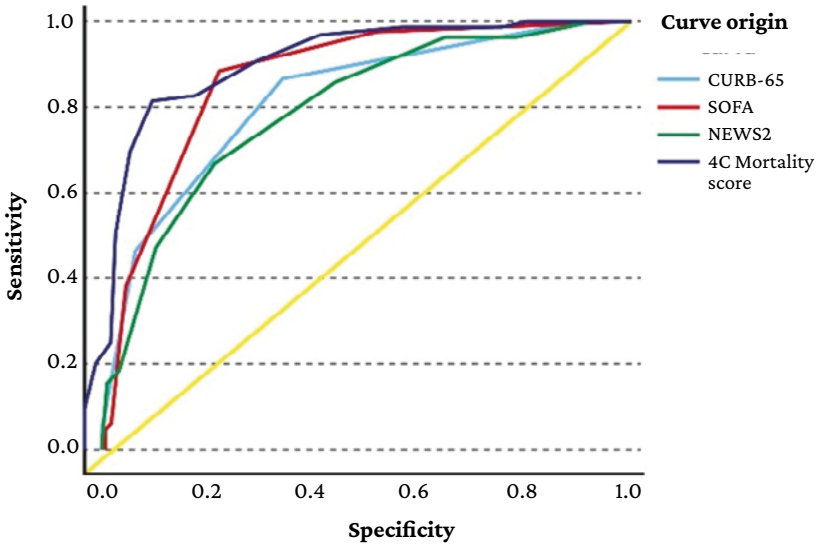

Figure 1. Comparison of the predictive performance of the CURB-65, SOFA, NEWS2, and 4C Mortality Score scales in predicting in-hospital mortality in patients with COVID-19.

Discussion

The present study found that the CURB-65, SOFA, NEWS2 and 4C Mortality Score scales had acceptable predictive performance for in-hospital mortality from COVID-19 within the first 30 days, with the 4C Mortality Score having the best performance, followed by the SOFA. However, it should be pointed out that, compared with the other scales, the 4C Mortality Score had a lower specificity and PPV, but a higher sensitivity and NPV.

Prognostic scales are valuable instruments for medical workers to identify patients at increased risk of mortality during clinical evaluation.[4] In the present study, the AUC of the 4C Mortality Score was 0.89, being this value higher than the one reported by Knight *et al.*[11] in their study, in which the scale was developed and validated (AUC=0.79, 95%CI: 0.78-0.79), as well as by Lazar-Neto *et al.*[15] (0.78), Doğanay & Ak[16] (0.78), Saad *et al.*[17] (0.76), and Jones *et al.*[18] (0.77). This difference could be explained by the ethnic differences of the populations compared; however, all studies agree that this scale is a valid instrument.

Furthermore, the sensitivity and specificity values of the 4C Mortality Score (cut-off point: ≥4) found in the present study were 99.90% and 15.40%, respectively. This is partially consistent with the findings reported for this scale by Lazar-Neto *et al.*,[15] who found a sensitivity of 99% and a specificity of 9% (cut-off point: 4) in a study of 1 363 patients hospitalized for COVID-19 pneumonia in Sao Paulo (Brazil) and Barcelona (Spain). It is also partially similar to the study conducted by Jones *et al.*[18] in 959 Canadian patients with COVID-19, in which sensitivity was 100% and specificity was 10.20% for a cut-off point >3. However, our specificity value was lower than the one reported by Knight *et al.*[11] in their study of 22 361 patients hospitalized for COVID-19, in which specificity was 38.60% (cut-off point: ≥9). Moreover, the NPV obtained in the present study for this scale was 99.90% (95%CI: 96.6-100.0), a figure similar to that reported in other studies where this value ranged from 97% to 100%.[15,18]

Considering these results, it could be stated that the 4C Mortality Score is a scale with a high predictive capacity for mortality, with high scores indicating a greater risk of this outcome. This could be related to the fact that this scale encompasses a series of sociodemographic, clinical and laboratory parameters that are altered in patients with severe COVID-19.

With respect to the SOFA scale (cut-off point: ≥3), in the present study we found an AUC of 0.87, a sensitivity of 98.10%, a specificity of 48.10%, a PPV of 34.90%, and a NPV of 98.90%. This AUC was similar to that found in other observational studies.[19-22] However, studies, such as the one conducted by Yoo *et al.*[23] in 4 840 patients with SARS-CoV-2 infection admitted between March 1 and April 28, 2020, to one of the 5 hospitals of the Mount Sinai Health System in New York (United States), and the one by Lalueza *et al.*,[24] conducted in 237 adults with COVID-19 hospitalized in Madrid on March 16, 2020, reported lower AUC values: 0.77 and 0.778 (cutoff point ≥2), respectively. Consequently, it is evident that the findings of most studies, including the present one, determine the high predictive performance of this scale.

On the other hand, in a study conducted in China with 140 critically ill patients with COVID-19, Liu *et al.*[20] reported that the SOFA (cut-off point: 3) had a lower sensitivity (90.00%), but a higher specificity (83.18%) and PPV (97.80%) compared to the present study. Similarly, Yang *et al.*[22] in China and Lalueza *et al.*[24] in Spain (cut-off points of 5 and 2) reported a specificity of 95.40% and 69.37%, respectively. However, the NPVs of those studies are high, a finding similar to that reported in our study.

In view of the above, it is evident that the SOFA scale is a valuable prognostic instrument in this population because it has an AUC very close to that of the 4C Mortality

Score. This could be related to the large number of parameters associated with multiple organ dysfunction, which favors the prediction of mortality because it facilitates the identification of patients in a more critical condition, who, in the case of COVID-19, would be those with severe disease and in whom the high inflammatory response and the activation of different mediators or cytokines would explain the alterations in each parameter evaluated.[20,22]

In the present study, the AUC of the CURB-65 scale was 0.82, which is similar to that reported in other studies (0.81-0.88).[9,16,21,25-29] However, Haimiovich *et al.*,[30] in a study of 1 171 patients with COVID-19, found a much lower AUC value: 0.50. Meanwhile, the sensitivity and NPV of the CURB-65 scale were 86.60% and 93.60%, respectively, and these values were similar to those found in other studies conducted by Wang *et al.*[21] in China (sensitivity: 83.8%, NPV: 96.1%) and Shi *et al.*[29] in the United States (sensitivity: 89.5%, NPV: 97.2%). However, our specificity (65.70%) was lower than the one established by Wang *et al.*[21] (73.7%) and higher than the one described by Shi *et al.*[29] (63.5%). Therefore, we infer that the CURB-65 scale provides good accuracy in identifying patients at low risk of mortality and, for this reason, is an acceptable instrument; moreover, due to the relative ease of obtaining its parameters, it is easier to apply in low-resource settings similar to ours.

Finally, the AUC of the NEWS2 scale was 0.80, a value similar to that reported by Fan *et al.*[25] in China (0.81) and by Martin-Rodriguez *et al.*[31] in Spain (0.82). In contrast, the AUC found for this scale by Bradley *et al.*[32] in a study using data from 830 patients with COVID-19 admitted to 7 hospitals in England was lower (0.67), which could be explained by the greater number of apparently normal clinical parameters in their sample.

In turn, the percentages of sensitivity, specificity, PPV, and NPV for the NEWS2 scale (cutoff point ≥7) found in the present study were 97%, 34.00%, 33.00%. and 97.20%, respectively. These values are similar to those reported by Bradley *et al.*,[32] who used a cut-off point ≥5 (83.00%, 37.00%, 43.00 % and 79.00%) in a study conducted in England, and by Myrstad *et al.*,[10] who used a cut-off point ≥6 (80.00%, 84.30%, 60.0%, 93.5%) in a Norwegian study of 66 hospitalized patients with confirmed SARS-CoV-2 infection. Considering the results of our study and those of comparable studies, there is evidence that the sensitivity of the NEWS2 scale varies in direct proportion to the established cut-off point, while specificity varies inversely.

Although the NEWS2 scale showed an acceptable predictive performance, it is pertinent to point out that its use could result in an underestimation of the patient with severe COVID-19 because this instrument does not consider oxygen requirements, so patients with hypoxic respiratory failure could have a lower score since their vital signs would be stable in all circumstances.

To the best of our knowledge, this is the first study comparing four in-hospital mortality prediction scales in patients with COVID-19 who were not admitted to an intensive care unit in Peru. Concerning its limitations, it is necessary to consider that the study is retrospective, that we worked with patients from a single healthcare center (due to the administrative difficulties associated with COVID-19 in hospitals of the region), and that it was not possible to calculate the SOFA score in all patients. Similarly, it should be noted that some parameters were not considered for establishing mortality risk, such as body mass index, inflammation markers, and radiological findings, because they were not evaluated in the selected scales.

Conclusions

The four scales evaluated had an acceptable performance for predicting in-hospital mortality in patients with COVID-19, with the 4C Mortality Score having the best performance as measured by the AUC, followed by the SOFA. These findings may suggest that the 4C Mortality Score, SOFA, NEWS2 and CURB-65 scales in patients hospitalized for COVID-19 are useful in the assessment of mortality risk.

Note: This study is derived from a thesis written by the first two authors to obtain the degree of physician in Peru.[33]

Conflicts of interest

None stated by the authors.

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References

1. World Health Organization (WHO). WHO Director-General's opening remarks at the media briefing on COVID-19 - 11 March 2020. Geneva: WHO; 2020 [cited 2024 Mar 20]. Available from: https://bit.ly/3PwExhE.
2. World Health Organization (WHO). Weekly Epidemiological Update on COVID-19. Edition 158 published 1 September 2023. Geneva: WHO; 2023 [cited 2024 Mar 20]. Available from: https://bit.ly/43sNE91.
3. Perú. Ministerio de Salud (MinSalud). Centro Nacional de Epidemiología, Prevención y Control de Enfermedades. Sala COVID-19. Actualización semanal. Lima: MinSalud; 2023 [cited 2023 Aug 28]. Available from: https://bit.ly/3PrlLbF.
4. Villanueva-Carrasco R, Domínguez-Samamés R, Salazar-De La Cruz M, Cuba-Fuentes MS. Respuesta del primer nivel de atención de salud del Perú a la pandemia COVID-19. An Fac med. 2020;81(3):337-41. https://doi.org/mm9w.
5. Yang X, Yu Y, Xu J, Shu H, Xia J, Liu H, *et al.* Clinical course and outcomes of critically ill patients with SARS-CoV-2 pneumonia in Wuhan, China: a single-centered, retrospective, observational study. Lancet Respir Med. 2020;8(5):475-81. https://doi.org/ggppq4.
6. Lim WS, Van der Eerden MM, Laing R, Boersma WG, Karalus N, Town GI, *et al.* Defining community acquired pneumonia severity on presentation to hospital: an international derivation and validation study. Thorax. 2003;58(5):377-82. https://doi.org/fsq7vh.
7. Vicent JL, Moreno R, Takala J, Willatts S, De Mendoça, Bruining H, *et al.* The SOFA (Sepsis-related Organ Failure Assesment) score to describe organ dysfunction/failure. On behalf of the Working Group on Sepsis-Related Problems of the European Society of Intensive Care Medicine. Intensive Care Med. 1996;22(7):707-10. https://doi.org/bpkxdw.
8. Royal College of Physicians. National Early Warning Score (NEWS 2). 2017. London: Royal College of Physicians; 2017 [cited 2024 Mar 20]. Available from: https://bit.ly/3TKlIdu.
9. Esteban-Ronda V, Ruiz-Alcaraz S, Ruiz-Torregrosa P, Giménez-Suau M, Nofuentes Pérez E, León Ramírez JM, *et al.* Aplicación de escalas pronósticas de gravedad en la neumonía por SARS-CoV-2. Med Clin (Barc). 2021;157(3):99-105. https://doi.org/gmzxwb.
10. 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;13;28(1):66. https://doi.org/gg4vpj.
11. Knight SR, Ho A, Pius R, Buchan I, Carson G, Drake TM, *et al.* Risk stratification of patients admitted to hospital with covid-19 using the ISARIC WHO Clinical Characterisation Protocol: development and validation of the 4C Mortality Score. BMJ. 2020;370:m3339. https://doi.org/ghbffd.

12. Perú. Instituto de Tecnologías en Salud e Investigación (IETSI), Seguro Social de Salud (ESSALUD). Guía de Práctica Clínica para el Manejo de COVID-19 (Adultos). Versión 3. Lima: IETSI; 2021 [cited 2024 Mar 20]. Available from: https://bit.ly/3VrhqZB.
13. World Medical Association (WMA). WMA Declaration of Helsinki – Ethical principles for medical research involving human subjects. Fortaleza: 64th WMA General Assembly; 2013.
14. Colombia. Ministerio de Salud. Resolución 8430 de 1993 (octubre 4): Por la cual se establecen las normas científicas, técnicas y administrativas para la investigación en salud. Bogotá D.C.; october 4 1993.
15. Lazar-Neto F, Marino LO, Torres A, Cilloniz C, Meirelles Marchini JF, Garcia de Alencar JC, *et al.* Community-acquired pneumonia severity assessment tools in patients hospitalized with COVID-19: a validation and clinical applicability study. Clin Microbiol Infect. 2021;27(7):1037.e1-1037.e8. https://doi.org/gmzxqp.
16. Doğanay F, Ak R. Performance of the CURB-65, ISARIC-4 and COVID-GRAM scores in terms of severity for COID-19 patients. Int J Clin Pract. 2021;75(10):e14759. https://doi.org/mm92.
17. Saad JE, Correa-Barovero MA, Marucco FA, Rodríguez-Bonazzi ST, Tarditi-Barra A, Zlotogora M, *et al.* Características clínicas y epidemiológicas de pacientes hospitalizados por infección por SARS-CoV-2 en dos hospitales en Córdoba. Revista de la Facultad de Ciencias Médicas de Córdoba. 2021;78(3):303-12. https://doi.org/mm94.
18. Jones A, Pitre T, Junek M, Kapralik J, Patel R, Feng E, *et al.* External validation of the 4C mortality score among COVID-19 patients admitted to hospital in Ontario, Canada: a retrospective study. Sci Rep. 2021;11(1):18638. https://doi.org/mm96.
19. Sottile P, Albers D, DeWitt P, Russell, Stroh JN, Kao DP, *et al.* Real-Time Electronic Health Record Mortality Prediction During the COVID-19 Pandemic: A Prospective Cohort Study. medRxiv. 2021. https://doi.org/mm97.
20. Liu S, Yao N, Qiu Y, He C. Predictive performance of SOFA and qSOFA for in-hospital mortality in severe novel coronavirus disease. Am J Emerg Med. 2020;38(10):2074-80. https://doi.org/gg4rsz.
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. Peer J. 2020;8:e10018. https://doi.org/gm663k.
22. Yang Z, Hu Q, Huang F, Xiong S, Sun Y. The prognostic value of the SOFA score in patients with COVID-19: A retrospective, observational study. Medicine (Baltimore). 2021;100(32):e26900. https://doi.org/mm99.
23. Yoo E, Percha B, Tomlinson M, Razuk V, Pan S, Basist M, *et al.* Development and calibration of a simple mortality risk score for hospitalized COVID-19 adults. medRxiv. 2020. https://doi.org/mnbb.
24. Lalueza A, Lora-Tamayo J, de la Calle C, Sayas-Catalán J, Arrieta E, Maestro G, *et al.* Utilidad de las escalas de sepsis para predecir el fallo respiratorio y la muerte en pacientes con COVID-19 fuera de las Unidades de Cuidados Intensivos. Rev Clin Esp. 2020;222(5):293-8 https://doi.org/mnbc.
25. Fan G, Tu C, Zhou F, Liu Z, Wang Y, Song B, *et al.* Comparison of severity scores for COVID-19 patients with pneumonia: a retrospective study. Eur Respir J. 2020;56(3):2002113. https://doi.org/gg5f6q.
26. Guo J, Zhou B, Zhu M, Yuan Y, Wang Q, Zhou H, *et al.* CURB-65 may serve as a useful prognostic marker in COVID-19 patients within Wuhan, China: a retrospective cohort study. Epidemiol Infect. 2020;148:e241. https://doi.org/grhbn4.
27. Satici C, Demirkol MA, Sargin-Altunok E, Gursoy B, Alkan M, Kamat S, *et al.* Performance of pneumonia severity index and CUB-65 in predicting 30-day mortality in patients with COVID-19. Int J Infect Dis. 2020;98:84-9. https://doi.org/ghc5js.
28. García-Clemente MM, Herrero-Huertas J, Fernández-Fernández A, De La Escosura-Muñoz C, Enríquez Rodríguez AI, Pérez Martínez L, *et al.* Assesment of risk scores in Covid-19. Int J Clin Pract. 2021;75(12):e13705. https://doi.org/mnbd.
29. Shi Y, Pandita A, Hardesty A, McCarthy M, Aridi J, Weiss ZF, *et al.* Validation of pneumonia prognostic scores in a statewide cohort of hospitalized patients with COVID-19. Int J Clin Pract. 2021;75(3):e13926. https://doi.org/gmzxq6.
30. Haimovich AD, Ravindra NG, Stoytchev S, Young HP, Wilson FP, van Dijk D, *et al.* Development and Validation of the Quick COVID-19 Severity Index: A Prognostic Tool fot Early Clinical Decompensation. Ann Emerg Med. 2020;75(4):442-53. https://doi.org/gg5xq3.
31. 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(3):170. https://doi.org/mnbf.
32. Bradley P, Frost F, Tharmaratnam K, Wootton D. 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(1):e000729. https://doi.org/gkn2kw.
33. Quispe-Ochoa DM, Flores-Quiroga RF. Capacidad predictiva de mortalidad hospitalaria de las escalas CURB-65, SOFA y NEWS2 en comparación de 4C Mortality Score, en pacientes con COVID-19 del servicio de Medicina Interna del Hospital Nacional Dos de Mayo en el periodo enero-junio del 2021 [Thesis]. Lima: Universidad Ricardo Palma; 2021.