Physiologic Scoring Systems in Predicting the COVID-19 Patients’ one-month Mortality; a Prognostic Accuracy Study

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Abstract: Introduction: It is critical to quickly and easily identify severe coronavirus disease 2019 (COVID-19) patients and predict their mortality. This study aimed to determine the accuracy of the physiologic scoring systems in predicting the mortality of COVID-19 patients. Methods: This prospective cross-sectional study was performed on COVID-19 patients admitted to the emergency department (ED). The clinical characteristics of the participants were collected by the emergency physicians and the accuracy of the Quick Sequential Failure Assessment (qSOFA), Coronavirus Clinical Characterization Consortium (4C) Mortality, National Early Warning Score-2 (NEWS2), and Pandemic Respiratory Infection Emergency System Triage (PRIEST) scores for mortality prediction was evaluated. Results: Nine hundred and twenty-one subjects were included. Of whom, 745 (80.9%) patients survived after 30 days of admission. The mean age of patients was 59.13 ± 17.52 years, and 550 (61.6%) subjects were male. Non-Survived patients were significantly older (66.02 ± 17.80 vs. 57.45 ± 17.07, P< 0.001) and had more comorbidities (diabetes mellitus, respiratory, cardiovascular, and cerebrovascular disease) in comparison with survived patients. For COVID-19 mortality prediction, the AUROCs of PRIEST, qSOFA, NEWS2, and 4C Mortality score were 0.846 (95% CI [0.821-0.868]), 0.788 (95% CI [0.760-0.814]), 0.843 (95% CI [0.818-0.866]), and 0.804 (95% CI [0.776-0.829]), respectively. All scores were good predictors of COVID-19 mortality. Conclusion: All studied physiologic scores were good predictors of COVID-19 mortality and could be a useful screening tool for identifying high-risk patients. The NEWS2 and PRIEST scores predicted mortality in COVID-19 patients significantly better than qSOFA.

Keywords: COVID-19; Clinical Decision Rules; Mortality; Emergency service, hospital

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1. Introduction

The coronavirus disease 2019 (COVID-19), a respiratory disease caused by the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), has unfolded globally with unheard-of rapidity (1). COVID-19 has had a devastating impact on health care, internationally (1, 2). 6 to 20% of sufferers need to be hospitalized (2, 3). The incidence of critical disorder...
amongst hospitalized patients is about 5-20%, and intensive care treatment may also be required in >25% of them (4, 5). The mortality rate amongst hospitalized subjects is estimated to be 11-28% (2, 6).

Therefore, it is essential to identify subjects that emerge as severely or even critically ill quickly and without problems, which can help in allocation of the limited medical and monitoring resources. Using scoring systems to estimate a patient’s risk of unfavorable outcome can decrease unnecessary use of the limited available resources (1, 2, 5). Several medical scoring tools have been used for risk stratification regarding sepsis and community-acquired pneumonia (CAP) (2, 5). There are several valid scoring systems for predicting pneumonia mortality. The Quick Sequential Failure Assessment (qSOFA) criteria were developed in 2016 (2, 5) to predict mortality in septic patients. Still, recent research has recommended that qSOFA is an effective tool to evaluate mortality risk in seriously ill subjects with a variety of diseases, especially in resource-constrained eventualities (7, 8).

The Coronavirus Clinical Characterization Consortium (4C) Mortality Score was developed by the International Severe Acute Respiratory and emerging Infections Consortium (IS-ARIC). It was used on adult hospitalized COVID-19 patients in England, Wales, and Scotland to predict 30-day mortality (9, 10).

In studies conducted on emergency department (ED) patients, the National Early Warning Score (NEWS) was the most accurate in predicting in-hospital mortality (11). In 2017, NEWS was updated to NEWS2 by adding new oxygen saturation (SpO2) scoring scale. NEWS2 is recommended by the Royal College of Physicians for use in COVID-19 patients (11) and is a standardized scoring tool developed to improve the detection of deterioration in acutely ill patients (12). NEWS2 has shown good ability in prediction of adverse outcomes in patients attending the ED with suspected COVID-19.

In 2021, Pandemic Respiratory Infection Emergency System Triage (PRIEST) tool was developed and validated among adult patients with suspected COVID-19 in ED to address any pandemic respiratory infection, including COVID-19. It was created by adding age, sex, and performance status to NEWS2 (13).

The present study was performed at the time of the circulation of the Delta variant. Previous studies have suggested that physiologic scoring systems are practical tools to assess mortality risk in critically ill patients (9-14).

Therefore, these scores can assist emergency physicians in predicting the mortality of COVID-19 hospitalized patients. This study was conducted to estimate and compare the accuracy of the qSOFA, 4C Mortality, NEWS2, and PRIEST scores in predicting the mortality of COVID-19 patients in the emergency department setting.

2. Methods

2.1. Study setting and design

This prospective cross-sectional study was conducted at Al-Zahra hospital (a university-affiliated, COVID-19 referral hospital) in Isfahan, Iran, between June 22, 2021, and November 21, 2021 (at the time of circulation of the Delta variant of the coronavirus). The clinical characteristics of the participants were collected by the emergency physicians and the accuracy of the Quick Sequential Failure Assessment (qSOFA), Coronavirus Clinical Characterization Consortium (4C) Mortality, National Early Warning Score-2 (NEWS2), and Pandemic Respiratory Infection Emergency System Triage (PRIEST) scores in prediction of one-month mortality was evaluated.

This study was approved by the ethics committee of Isfahan University of Medical Sciences (code: IR.MUI.MED.REC.1399.932), and the study participants signed the informed consent.

2.2. Participants

Adult subjects (over 18 years of age) with confirmed COVID-19 infection, who were admitted to the emergency department (ED) of Al-Zahra hospital were eligible for study participation. COVID-19 infection was established according to the WHO interim guidance (15). Pregnant patients, those who disagreed to participate in the study, those hospitalized for other medical conditions unrelated to COVID-19, and patients transferred from other hospitals were excluded.

2.3. Data collection

The emergency medicine residents evaluated and managed the patients in the ED based on the standard protocol at Al-Zahra Hospital. The patients’ demographic information (gender and age), baseline variables, and clinical and laboratory data were collected on ED admission. Clinical data including signs and symptoms, blood pressure (BP), respiratory rate (RR), heart rate (HR), AVPU (‘Alert’, ‘Voice’, ‘Pain’, ‘Unresponsive’), temperature, O2 saturation (SpO2), laboratory findings, and triage level based on Emergency Severity Index (ESI) version 4, and chest computed tomography (CT) scans were recorded. These data were extracted to calculate the qSOFA, 4C Mortality, NEWS2, and PRIEST scores. The primary outcome was mortality within 30 days after admission to the ED.

The qSOFA consists of three parameters. One point is allotted to each variable: SBP ≤100 mm Hg, RR ≥22 breaths/minute, and altered mental status (GCS<15). The score ranges from 0 to 3 (7).

The NEWS2 tool comprises six physiological variables (RR, SpO2, SBP, HR, level of consciousness or new confusion, and temperature). Each variable is scored from 0 to 3. Finally, two
points are added for patients requiring supplementary oxygen treatment (11) (Appendix 1). The NEWS-2 assessment categorizes patients into low risk (0–4), medium risk (5–6), and high risk (≥7).

The PRIEST score can be calculated by adding age and gender, and performance status to the parameters of the NEWS2 score (Appendix 1). The score ranges from zero to 29 points (13).

The 4C Mortality Score includes eight variables (age, sex, number of comorbidities, RR, SpO2, GCS, BUN level, and C-reactive protein level) (Appendix 2). The total score ranges between 0 and 21 points (9).

2.4. Statistical analysis

Based on similar studies (2), assuming specificity of 80%, the mortality rate of 20%, the estimation accuracy of 95%, and type-1 error of 3%, the minimum required sample size was 853 people. SPSS software version 25.0 (IBM, Armonk, NY) was applied to analyze the variables. Categorical data were described as frequency (%), and continuous data were expressed as mean and standard deviation (SD) or 95% confidence interval (CI). Chi-square test and Student's t-test, or the Mann-Whitney U test were performed to compare variables. The area under a receiver operating characteristic (AUROC) curve was calculated to evaluate and compare the effectiveness of the qSOFA, 4C Mortality, NEWS2, and PRIEST scores in predicting mortality. P-value less than 0.05 in two-tailed tests was considered significant.

3. Results

3.1. Patients' baseline characteristics

Nine hundred and twenty-one subjects were included in this study. Of them, 745 (80.9%) patients had survived 30 days after admission. The mean age of patients was 59.13 ± 17.52 years, and 550 (61.6%) subjects were male. The mean length of hospital stay was 8.69 ± 8.91 days. The most common underlying diseases were hypertension (32.6%) and diabetes (32.2%). The most common symptoms on admission were dyspnea (72.6%) and fever (65.1%). The baseline characteristics and laboratory parameters of survived and non-survived patients are compared in table 1 and 2.

Non-Survived patients were significantly older (66.02 ± 17.80 vs. 57.45 ± 17.07, P< 0.001) and had more comorbidities (diabetes mellitus, respiratory, cardiovascular, and cerebrovascular disease) in comparison with survived patients. Among vital parameters on ED admission, SpO2, RR and HR significantly differed between survived and non-survived patients. There were significant differences between survivor and non-survivor patients regarding GCS, length of hospital stay, qSOFA, PRIEST, NEWS2, and 4C Mortality scores. The lymphocyte counts and hemoglobin in non-survived patients were significantly lower than survived patients (P < 0.001). The d-Dimer, blood sugar, and Lactate Dehydrogenase levels in non-survived patients were significantly higher than those who survived.

3.2. Comparing the Accuracy of scoring systems

ROC curves were drawn to calculate the sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and cut-off values of scores to predict COVID-19 mortality. The optimal cut-off values of ≥2 for the qSOFA, ≥8 for PRIEST, ≥6 for NEWS2, and ≥13 for the 4C Mortality score were established. The NPV of the PRIEST, qSOFA, NEWS2, and 4C Mortality scores for mortality were 96.0%, 95.2%, 94.0%, and 91.5%, respectively (Table 3).

For COVID-19 mortality prediction, the AUROCs of PRIEST, qSOFA, NEWS2, and 4C Mortality score were 0.846 (95% CI [0.821-0.868]), 0.788 (95% CI [0.760-0.814]), 0.843 (95% CI [0.818-0.866]), and 0.804 (95% CI [0.776-0.829]), respectively. All scores were good predictors of COVID-19 mortality (Figure 1). The AUROC analysis showed that the NEWS2 and PRIEST scores were more successful than qSOFA (P=0.004 and P=0.001) in predicting mortality for COVID-19 patients (Table 4).

4. Discussion

Due to the limitations of medical resources during the COVID-19 outbreak, it is essential to initially assess COVID-19 patients in terms of disease severity to ensure primary medical management and interventions. Therefore, one of
Table 1  Comparison of demographic and clinical characteristics of COVID-19 patients based on 30-day mortality

| Characteristics               | Total (n=921) | Survived (n=745) | Non-Survived (n=176) | P     |
|------------------------------|---------------|------------------|----------------------|-------|
| Age (year)                   | 59.13 ± 17.52 | 57.45 ± 17.07    | 66.02 ± 17.80        | 0.001 |
| Gender                       |               |                  |                      |       |
| Male                         | 550 (61.6)    | 436 (58.5)       | 114 (64.8)           | 0.128 |
| Female                       | 371 (38.4)    | 309 (41.5)       | 62 (35.2)            |       |
| Comorbidities                |               |                  |                      |       |
| Respiratory disease          | 127 (13.8)    | 82 (11.0)        | 45 (25.6)            | <0.001|
| Cardiovascular disease       | 164 (17.8)    | 122 (16.4)       | 42 (23.9)            | 0.032 |
| Diabetes mellitus            | 294 (32.2)    | 219 (29.3)       | 75 (42.6)            | 0.001 |
| Hypertension                 | 300 (32.6)    | 236 (31.7)       | 64 (36.4)            | 0.357 |
| Cerebrovascular disease      | 84 (9.1)      | 54 (7.2)         | 30 (17.0)            | 0.001 |
| Chronic kidney disease       | 98 (10.6)     | 77 (10.3)        | 21 (11.9)            | 0.413 |
| Chronic liver disease        | 27 (2.9)      | 21 (2.8)         | 6 (3.4)              | 0.452 |
| Malignancy                   | 76 (8.3)      | 55 (7.4)         | 21 (11.9)            | 0.053 |
| Signs and symptoms           |               |                  |                      |       |
| Fever                        | 600 (65.1)    | 499 (67.0)       | 101 (57.4)           | 0.041 |
| Cough                        | 549 (59.8)    | 448 (60.1)       | 101 (57.4)           | 0.537 |
| Dyspnea                      | 669 (72.6)    | 542 (72.8)       | 127 (72.2)           | 0.874 |
| Fatigue                      | 497 (54.0)    | 412 (55.3)       | 85 (48.3)            | 0.093 |
| Sore throat                  | 84 (9.12)     | 67 (9.90)        | 17 (9.66)            | 0.388 |
| Myalgia                      | 208 (22.6)    | 178 (23.9)       | 30 (17.0)            | 0.051 |
| Diarrhea                     | 215 (23.3)    | 188 (25.2)       | 27 (15.3)            | 0.005 |
| Opioid                       | Yes           | 91 (9.9)         | 70 (9.4)             | 0.593 |
| Glasgow coma scale           |               |                  |                      |       |
| Mean ± SD                    | 11.61±2.03    | 12.32 ± 6.92     | 10.02 ± 2.67         | <0.001|
| Length of stay (day)         |               |                  |                      |       |
| Mean ± SD                    | 8.68±8.91     | 8.06 ± 7.39      | 11.23 ±13.26         | 0.003 |
| Vital parameters             |               |                  |                      |       |
| HR; bpm                      | 88.04±12.41   | 87.25±11.91      | 91.31±13.92          | 0.043 |
| SBP; mmHg                    | 23.53±17.64   | 23.95±17.87      | 21.81±16.71          | 0.463 |
| DBP; mmHg                    | 75.71±11.56   | 75.84±11.71      | 75.19±11.04          | 0.864 |
| RR; bpm                      | 20.59±3.09    | 20.31±2.88       | 21.76±3.65           | 0.001 |
| Temp; °c                     | 37.34 ± 0.61  | 37.33±0.63       | 37.37±0.51           | 0.312 |
| SpO2; %                      | 88.99±6.06    | 91.40±6.03       | 80.31±5.95           | 0.001 |
| Scores                       |               |                  |                      |       |
| qSOFA                        | 1.46±0.61     | 1.33±0.53        | 2.04±0.57            | <0.001|
| PRIEST                       | 7.15±2.92     | 6.61±2.72        | 9.42±2.66            | <0.001|
| 4CMortality                  | 10.42±3.70    | 9.67±3.52        | 13.58±2.63           | <0.001|
| NEWS2                        | 4.81±2.70     | 4.17±2.34        | 7.54±2.40            | <0.001|

Data are presented as mean ± standard deviation (SD) or frequency (%). HR: heart rate; SBP: systolic blood pressure; DBP: diastolic blood pressure; RR: respiratory rate; temp: temperature; SpO2: oxygen saturation.

the most critical tasks of emergency physicians is rapid and accurate screening of subjects at risk of death in severe or critically ill COVID-19 patients to provide them with additional monitoring, intervention, or intensive care (16). In such situations, scoring systems can help overcome limitations. Each scoring tool has its advantages and disadvantages.

The 30-day mortality in the current study was high (19.1%). It was in line with previous studies (ranging from 19.2% to 20.9%) (2, 6, 10). Consistent with the current study, previous studies have shown that non-survived COVID-19 patients were significantly older, had a higher respiratory rate, a lower SpO2 on ED arrival, and had more underlying diseases than those who survived (2, 5, 8, 11).

Most patients presented with respiratory tract symptoms such as dyspnea and cough, fever, and fatigue. Previous studies reported that the most common symptoms include cough (60–86%), dyspnea (53–80%), and taste or smell disturbance (64–80%) (10, 17-19). These results are similar to the present study.

The current study has compared the performance of four different scoring systems in predicting COVID-19 mortality. The NEWS2 and PRIEST, with AUROC of 0.843 and 0.846 in predicting mortality of COVID-19 patients, are significantly
### Table 2
Comparing the laboratory parameters of the COVID-19 patients at the time of admission between survived and non-survived

| Characteristics                  | Total (n=921) | Survived (n=745) | Non-Survived (n=176) | P    |
|----------------------------------|---------------|------------------|----------------------|------|
| White blood cells, ×10^9 /ml     | 7.096±4.279   | 6.964 ± 4.089    | 7.656±5.010          | 0.125|
| Lymphocytes, ×10^9 /ml           | 1.59±0.91     | 1.71 ± 0.88      | 1.90 ± 0.87          | <0.001|
| Hemoglobin, g/L                  | 13.41±2.13    | 13.03 ± 1.86     | 15.00 ± 2.46         | <0.001|
| Platelets, ×10^9 /ml             | 182.6±81.8    | 183.2±82.5       | 179.8±79.5           | 0.721|
| PaO₂, mmHg                       | 45.60±23.03   | 46.60±23.70      | 41.48±19.72          | 0.012|
| PH                               | 7.32±0.10     | 7.31 ± 0.09      | 7.37±0.10            | <0.001|
| PaCO₂                            | 41.50±12.10   | 41.72±11.69      | 40.61±13.71          | 0.280|
| HCO₃                             | 21.29±4.85    | 21.29±4.79       | 21.27±5.12           | 0.803|
| ALT, U/L                         | 44.45±27.31   | 45.20±27.17      | 41.33±27.91          | 0.352|
| AST, U/L                         | 55.16±23.38   | 54.26±22.97      | 58.79±24.81          | 0.185|
| BUN, mmol/L                      | 20.13±12.69   | 19.74±12.38      | 21.79±13.95          | 0.476|
| Creatinine, umol/L               | 1.59±1.44     | 1.59±1.17        | 1.61±0.98            | 0.973|
| Potassium, mmol/L                | 4.68±1.23     | 4.69±1.32        | 4.64±0.79            | 0.985|
| Sodium, mmol/L                   | 13.14±7.86    | 13.26±8.35       | 13.65±5.47           | 0.130|
| Ferritin, g/L                    | 528.1±380.2   | 519.3±391.0      | 579.5±311.8          | 0.235|
| d-Dimer                          | 910.5±841.0   | 881.5±851.7      | 1018.6±798.2         | <0.001|
| Blood sugar                      | 130.28±57.26  | 127.59±59.71     | 141.50±44.38         | <0.001|
| Creatine kinase                  | 308.1±411.3   | 303.9±405.6      | 326.9±440.1          | 0.929|
| Lactate Dehydrogenase            | 672.6±310.0   | 646.5±280.4      | 776.9±393.3          | 0.019|
| C-reactive protein               | 68.15±44.11   | 67.88±44.85      | 69.28±41.23          | 0.880|
| ESR                              | 48.87±25.94   | 49.20±25.56      | 47.54±23.41          | 0.696|

Data are presented as mean ± standard deviation (SD). ALT: Alanine aminotransferase; AST: Aspartate aminotransferase; BUN: Blood Urea Nitrogen; ESR: erythrocyte sedimentation rate.

### Table 3
Screening performance characteristics of physiologic scoring systems in predicting the 30-day mortality of COVID-19 patients

| Variables            | 4C Mortality | NEWS2 | qSOFA | PRIEST |
|----------------------|--------------|-------|-------|--------|
| Cut-off              | ≥13          | ≥6    | ≥2    | ≥8     |
| Sensitivity          | 68.75 (61.3 - 75.5) | 78.98 (72.2 - 84.7) | 85.80 (79.7 - 90.6) | 87.50 (81.7 - 92.0) |
| Specificity          | 79.19 (76.1 - 82.1) | 77.76 (74.6 - 80.7) | 68.87 (63.3 - 70.2) | 71.05 (67.6 - 74.3) |
| PPV                  | 43.8 (39.7 - 48.1) | 45.7 (41.9 - 49.6) | 37.9 (35.2 - 40.8) | 41.6 (38.6 - 44.7) |
| NPV                  | 91.5 (89.6 - 93.1) | 94.0 (92.1 - 95.4) | 95.2 (93.2 - 96.6) | 96.0 (94.2 - 97.3) |
| PLR                  | 3.30 (2.78 - 3.92) | 3.55 (3.04 - 4.15) | 2.59 (2.30 - 2.91) | 3.02 (2.67 - 3.43) |
| NLR                  | 0.39 (0.32 - 0.49) | 0.27 (0.20 - 0.36) | 0.21 (0.15 - 0.31) | 0.18 (0.12 - 0.28) |
| AUC                  | 0.804 (0.776-0.829) | 0.843 (0.818-0.866) | 0.788 (0.760-0.814) | 0.846 (0.821-0.868) |

Data are presented with 95% confidence intervals. PPV: Positive predictive value; NPV: Negative predictive value; PLR: Positive Likelihood Ratio; NLR: Negative Likelihood Ratio; and AUC: Area Under the receiver operating characteristic Curve.

### Table 4
Comparison of the area under the receiver operating characteristic curve of different scoring systems in predicting the 30-day mortality of COVID-19 patients

|                      | qSOFA | PRIEST | 4C   | NEWS2 |
|----------------------|-------|--------|------|-------|
| qSOFA                | –     | 0.001  | 0.357| 0.004 |
| PRIEST               | –     | 0.021  | 0.670| –     |
| 4C                   | –     | –      | 0.073| –     |
| NEWS2                | –     | –      | –    | –     |

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can be used as a triage tool to predict the mortality of COVID-19 patients and allocate the limited resources.

The diagnostic ability of qSOFA for the prediction of hospital mortality in the current study (AUROC=0.788) was comparable to Liu et al. (AUROC=0.742), Wilfong et al. (AUROC=0.801), and Jang et al. (AUROC=0.779) in COVID-19 patients (16, 22, 23). These findings showed that qSOFA is quite a good tool for predicting hospital mortality in COVID-19 patients.

The PRIEST study examined 20,891 suspected COVID-19 patients in 70 emergency departments. Triage scores provided good but not excellent discrimination with good sensitivity at the expense of specificity in patients with suspected COVID-19 (24). This study did not suggest any cut-off point to apply for decision-making in COVID-19 patients. Goodacre et al. demonstrated that PRIEST scores ≥5 predicted 30-day mortality with 98% sensitivity (13). Marincowitz et al. reported that the NEWS2 and PRIEST scores achieved high estimated sensitivities concerning 30-day mortality (14). In the present study, the additional components of the PRIEST score improved sensitivity and NPV.

The 4C Mortality score has been validated in over 57,000 patients in previous studies in several settings (4, 9, 10, 25, 26). The AUROC of the 4C Mortality score in the present study (0.804 [95% CI, 0.776-0.829]) is consistent with the results of previous studies in other countries. The AUROC of the 4C Mortality score was 0.84 (95% CI, 0.79-0.88) in a Dutch population (25), 0.78 (95% CI, 0.75-0.81) in a Brazilian and Spanish population (26), and 0.85 (95% CI, 0.79-0.89) in a United States population (27).

Citu et al. showed that the NEWS with an AUROC of 0.861 predicted mortality in COVID-19 patients and was significantly superior to the 4C Mortality score (AUROC = 0.818) (28). Ocho et al. demonstrated that for mortality prediction, AUROC of the 4C Mortality score (0.84 [95% CI, 0.76-0.92]) was higher than qSOFA (0.66 [95% CI, 0.53-0.78]) (29). These results were similar to the present study. Therefore, the 4C Mortality score is a useful tool to assess mortality risk in COVID-19 patients.

The NPV of the PRIEST, qSOFA, NEWS2, and 4C Mortality scores for in-hospital mortality were 96.0%, 95.2%, 94.0%, and 91.5%, respectively. The high NPV acts as a gatekeeper accurately identifying low-risk patients. The PRIEST had the highest sensitivity and NPV for mortality prediction. Thus, it is particularly well in identifying COVID-19 patients who were at low risk of death. For triaging patients in the ED, it is important to have a high NPV for predicting severe COVID-19 to avoid inappropriately admitting patients at risk of deterioration to a non-critical care area.

The PRIEST, qSOFA, and NEWS2 scores are calculated without laboratory tests or diagnostic imaging, while the 4C Mortality score needs laboratory tests. Therefore, the 4C Mortality score is more time-consuming than others. The PRIEST, qSOFA, and NEWS2 scores can predict patient deterioration quickly and simply in COVID-19 patients who need immediate treatment to minimize mortality in COVID-19 patients. Although a single evaluation on hospital admission has limited predictive ability, these scores could be a helpful screening tool to evaluate COVID-19 patients at the time of ED arrival. However, these should only supplement and not replace clinical judgment.

Due to silent hypoxemia in severe COVID-19, the accuracy of the qSOFA score in predicting hospital mortality decreases. These patients appear to breathe comfortably even at low SpO2. This score only counts the respiratory rate and does not consider SpO2. Therefore, it has limitations in predicting mortality in COVID-19 patients. An advantage of other scores compared to the qSOFA is that both hypoxemia and respiratory rate are included as scoring parameters.

5. Limitations

Our study has some limitations. A convenience sampling method was used, and the researcher was present in the ED, which may have caused selection bias. This study was a single-center study with limited generalizability, and the findings may not apply to other environments with different populations or healthcare systems. Additionally, the value of a single evaluation is limited, and patients admitted to the hospital should be reassessed frequently for signs of deterioration.

6. Conclusion

All studied physiologic scores were good predictors of COVID-19 mortality and these can be considered a useful screening tool to identify the high-risk patients. The NEWS2 and PRIEST scores predicted mortality in COVID-19 patients significantly better than qSOFA.

7. Declarations

7.1. Acknowledgments

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7.2. Authors’ contributions

All authors: Contributed to conception, study design, and data collection and evaluation. E.H. and M.Z.; Contributed to statistical analysis and interpretation of data. E.H. and M.Z.; Drafted the manuscript, which was revised by S.A., K.S., and S.M. All authors read and approved the final manuscript.
7.3. Availability of data and materials
The datasets used and analyzed during the current study are available from the corresponding author on reasonable request.

7.4. Ethics approval and consent to participate
This study was approved by the ethics committee of Isfahan University of Medical Sciences (code: IR.MUI.MED.REC.1399.932), and the study participants signed the informed consent.

7.5. Funding
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7.6. Competing interests
The authors declare no conflict of interest.

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### Appendix I: National Early Warning Score-2 (NEWS2) and Pandemic Respiratory Infection Emergency System Triage (PRIEST)

| Variable                          | Categories                  | Points |
|-----------------------------------|-----------------------------|--------|
| **Respiratory rate, breaths per minute** | ≤8                          | 3      |
|                                   | 9–11                        | 1      |
|                                   | 12–20                       | 0      |
|                                   | 21–24                       | 2      |
|                                   | ≥25                         | 3      |
| **SpO2 (on room air or supplemental)** | ≤91%                        | 3      |
|                                   | 92–93%                      | 2      |
|                                   | 94–95%                      | 1      |
|                                   | ≥96%                        | 0      |
| **Oxygen**                        | Supplemental oxygen         | 2      |
|                                   | Room air                    | 0      |
| **Temperature**                   | ≤35.0 °C                    | 3      |
|                                   | 35.1–36.0 °C                | 1      |
|                                   | 36.1–38.0 °C                | 0      |
|                                   | 38.1–39.0 °C                | 1      |
|                                   | ≥39.1 °C                    | 2      |
| **Systolic Blood Pressure, mm Hg** | ≤90                         | 3      |
|                                   | 91–100                      | 2      |
|                                   | 101–110                     | 1      |
|                                   | 111–219                     | 0      |
|                                   | ≥220                        | 3      |
| **Pulse Rate, beats per minute**  | ≤40                         | 3      |
|                                   | 41–50                       | 1      |
|                                   | 51–90                       | 0      |
|                                   | 91–110                      | 1      |
|                                   | 111–130                     | 2      |
|                                   | ≥131                        | 3      |
| **Consciousness**                 | Alert                       | 0      |
|                                   | Confused or not alert       | 3      |
| **Age in years**                  | 16–49                       | 0      |
|                                   | 50–65                       | 2      |
|                                   | 66–80                       | 3      |
|                                   | ≥80                         | 4      |
| **Sex**                           | Female                      | 0      |
|                                   | Male                        | 1      |
| **Performance status**            | Unrestricted normal activity| 0      |
|                                   | Limited strenuous activity, can do light activity| 1 |
|                                   | Limited activity, can self-care| 2 |
|                                   | Limited self-care           | 3      |
|                                   | Bed/chair bound, no self-care| 4 |

*It is only used in the PRIEST score.*
## Appendix 2: Coronavirus Clinical Characterization Consortium (4C) Mortality Score

| Variable                                | Points |
|-----------------------------------------|--------|
| **Age in years**                        |        |
| < 50                                    | 0      |
| 50–59                                   | 2      |
| 60–69                                   | 4      |
| 70–79                                   | 6      |
| ≥80                                     | 7      |
| **Sex at birth**                        |        |
| Female                                  | 0      |
| Male                                    | 1      |
| **Number of comorbidities**             |        |
| 0                                       | 0      |
| 1                                       | 1      |
| ≥2                                      | 2      |
| **Respiratory rate (/minute)**          |        |
| <20                                     | 0      |
| 20–29                                   | 1      |
| ≥30                                     | 2      |
| **Peripheral oxygen saturation on room air** |    |
| ≥92%                                    | 0      |
| <92%                                    | 2      |
| **Glasgow coma scale**                  |        |
| 15                                      | 0      |
| <15                                     | 2      |
| **Urea/ Blood Urea Nitrogen**           |        |
| Urea <7 mmol/L or BUN <19.6 mg/dL       | 0      |
| Urea 7–14 mmol/L or BUN 19.6–39.2 mg/dL | 1      |
| Urea >140 mmol/L or BUN >39.2 mg/dL     | 3      |
| **C-reactive protein**                  |        |
| < 50 mg/L                               | 0      |
| 50–99 mg/L                              | 1      |
| ≥100 mg/L                               | 2      |