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ORIGINAL ARTICLE
ORİJİNAL ARAŞTIRMA

Do We Have a Precise Severity Scoring System for Predicting the Prognosis of COVID-19?

COVID-19'un Prognozunu Tahmin Etmek İçin Kesin Bir Şiddet Derecelendirme Sistemimiz Var mı?

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ABSTRACT

Aim: The COVID-19 pandemic, caused by SARS-CoV-2, has posed unprecedented challenges to healthcare systems worldwide. Effective risk stratification tools are essential for clinical decision-making and resource allocation. This study aimed to evaluate and compare the performance of three clinical severity scoring systems: PRIEST COVID-19 Clinical Severity Score, 4C Mortality Score for COVID-19, and Pneumonia Severity Index (PSI) in predicting mortality and disease severity in patients presenting to the emergency department with COVID-19.

Material and Method: A prospective, single-center study was conducted at a tertiary-level Training and Research Hospital in Izmir, Turkey, between December 2020 and December 2021. Patients with clinical symptoms and confirmed COVID-19 diagnosis were included. Demographic, clinical, and laboratory data were collected. The three scoring systems were calculated, and their predictive abilities for mortality, PCR positivity, and patient care needs were assessed using statistical analyses, including ROC curve analysis.

Results: None of the scoring systems demonstrated significant predictive power for PCR positivity. However, both the 4C Mortality Score and PSI showed robust and statistically significant predictive performance for mortality, with AUCs exceeding 80%. These systems could effectively differentiate patients' care needs, with the 4C score particularly useful for ward admission decisions (AUC >9.5). In patients not requiring oxygen support, all three scoring systems exhibited statistically significant results, aiding in early identification of patients less likely to deteriorate.

Discussion: Our findings highlight the limited utility of these scoring systems for diagnosing COVID-19 but emphasize their valuable role in predicting mortality and differentiating care needs. Importantly, there were no significant differences in the predictive performance among the scoring systems, suggesting interchangeability. These tools offer valuable guidance to healthcare providers in patient management, resource allocation, and risk stratification. Further research across diverse clinical settings is warranted, considering the evolving pandemic landscape and the introduction of new therapeutics and vaccines. These clinical severity scoring systems serve as essential tools in the ongoing fight against the COVID-19 pandemic, contributing to more effective clinical decision-making and improved patient outcomes.

Keywords: PRIEST COVID-19, 4C Mortality Score for COVID-19, Pneumonia Severity Index (PSI), mortality

ÖZ

Giriş: SARS-CoV-2'nin neden olduğu COVID-19 pandemisi, dünya çapında sağlık sistemlerine eşi benzeri görülmemiş zorluklar getirmiştir. Etkili risk katmanlandırma araçları, klinik karar verme ve kaynak tahsisi için çok önemlidir. Bu çalışma, üç klinik şiddet skorlama sisteminin performansını değerlendirmeyi ve karşılaştırmayı amaçlamıştır: PRIEST COVID-19 Klinik Şiddet Skoru, COVID-19 için 4C Mortalite Skoru ve Pnömoni Şiddet İndeksi (PSI), acil servise COVID-19 ile başvuran hastalarda mortalite ve hastalık şiddetini öngörmede.

Gereç ve Yöntem: Aralık 2020 ve Aralık 2021 tarihleri arasında İzmir'de üçüncü basamak bir Eğitim ve Araştırma Hastanesinde prospektif, tek merkezli bir çalışma yürütülmüştür. Klinik semptomları olan ve COVID-19 tanısı doğrulanmış hastalar çalışmaya dahil edildi. Demografik, klinik ve laboratuvar verileri toplandı. Üç skorlama sistemi hesaplandı ve bunların mortalite, PCR pozitifliği ve hasta bakım ihtiyaçları için öngörme yetenekleri, ROC eğrisi analizi de dahil olmak üzere istatistiksel analizler kullanılarak değerlendirildi.

Sonuçlar: Skorlama sistemlerinin hiçbiri PCR pozitifliği için anlamlı tahmin gücü göstermemiştir. Bununla birlikte, hem 4C Mortalite Skoru hem de PSI, AUC'leri %80'i aşan mortalite için güçlü ve istatistiksel olarak anlamlı tahmin performansı göstermiştir. Bu sistemler hastaların bakım ihtiyaçlarını etkili bir şekilde ayırt edebilmiş, 4C skoru özellikle servise kabul kararları için faydalı olmuştur (AUC >9,5). Oksijen desteği gerektirmeyen hastalarda, her üç skorlama sistemi de istatistiksel olarak anlamlı sonuçlar sergilemiş ve kötüleşme olasılığı daha düşük olan hastaların erken belirlenmesine yardımcı olmuştur.

Anahtar Kelimeler: PRIEST COVID-19, COVID-19 için 4C Mortalite Skoru, Pnömoni Şiddet İndeksi (PSI), mortalite

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INTRODUCTION

Coronavirus Disease (2019). (COVID-19) is a viral respiratory disease caused by the novel coronavirus (2019-nCoV), which has caused a pneumonia outbreak worldwide (1-3). It has affected the whole world and is still causing new cases and new deaths (4). Coronavirus 2 (SARS-CoV-2) infection causes deaths by causing severe respiratory failure (5). The recent increase in COVID-19 cases and the addition of new variants have brought this disease to the agenda again. Risk classifications that will ensure early identification of patients infected with SARSCoV-2 with the highest risk of death and patient and resource management have become necessary (6).

STEVE GOODACRE ET AL. DESIGNED the PRIEST COVID-19 Clinical Severity Score as a disease severity score based on clinical assessment alone to predict adverse outcomes in adult patients with suspected COVID-19 infection. It includes age, gender, respiratory rate, oxygen saturation, heart rate, systolic blood pressure, fever, state of consciousness, need for oxygen therapy, and activity capacity parameters (7).

4C Mortality Score for COVID-19 was developed by Stephen R Knight et al. to predict hospital mortality using clinical information and laboratory values routinely used at patient admission in patients hospitalized due to COVID-19. It includes age, gender, number of comorbidities, respiratory rate, oxygen saturation in room air, Glasgow coma score, BUN, and CRP parameters (8).

Pneumonia Severity Index (PSI) was developed to help differentiate the severity of the disease, low- or high-risk patients and to help decide on hospitalization or discharge in community-acquired pneumonia. It includes age, gender, home care needs, cancer, liver disease, heart failure, cerebrovascular disease, cerebrovascular disease, presence or absence of renal disease, respiratory rate, blood pressure, confusion, fever, pulse, pH, BUN, sodium, glucose, hematocrit, partial oxygen pressure, pleural effusion parameters (9).

This study aimed to investigate the success of the PRIEST COVID-19 Clinic Severity Score, 4C Mortality Score for COVID-19, which were created using clinical and laboratory tests in patients admitted to the emergency department due to COVID-19 disease, in evaluating the severity of the disease, the possibility of Mortality, and the necessity of hospitalization or discharge by comparing them with the Pneumonia Severity Index (PSI).

MATERIAL METHOD

Study Design

Our research was carried out as a prospective, single-center study in the Emergency Medicine Clinic of a tertiary-level Training and Research Hospital in the Izmir province between the years of December 2020 and December 2021. Izmir Katip Çelebi University's Ethics Committee gave their stamp of approval (24.06.2021/0296), which was necessary to move forward with the study. Face-to-face interviews were used to gain the consent of all of the study participants who volunteered to take part in the research. At each and every step of the research process, the Declaration of Helsinki was adhered to.

Study Population

Patients who presented to the emergency department with clinical symptoms and signs of COVID-19 and were diagnosed with COVID-19 by PCR test or Thorax CT were included in the study. Patients who did not present with COVID-19 clinical symptoms and signs were excluded. Patients who had data that was missing important information or patients whose consent could not be obtained were not included in the study.

Study protocol and Data collection

The demographic information, vital values, and exitus or intensive care hospitalization information of the patients who presented themselves to the emergency department of our hospital due to a suspicion of COVID-19 and were later diagnosed with COVID-19 disease were recorded on the case form that was created. This information was recorded on the case form that was created. In addition to this, the details of the patients' COVID-19 disease treatment were also written down. We used probel, the computer automation system that the hospital uses, to determine the protocol numbers in order to scan the patient cards, laboratory results, and consultation notes that were available in the system. The data that were obtained were input into the Excel template's appropriate cells. The PRIEST COVID-19 Clinic Severity Score, the 4C Mortality Score for COVID-19, and the Pneumonia Severity Index (PSI) were all determined through the use of calculations.

Statistical Analysis

Data were analyzed using the statistical package program IBM SPSS Statistics Standard Concurrent User V 26 (IBM Corp., Armonk, New York, USA). Descriptive statistics (M) were given as interquartile range (IQR) values. In addition, homogeneity of variances, one of the prerequisites of parametric tests, was checked by "Levene" test. The normality assumption was checked with the "Shapiro-Wilk" test. "Mann Whitney-U test" was used when differences between two groups were to be evaluated. The "Roc Curve" analysis method was used to compare the diagnostic performance of two or more diagnostic or laboratory tests. When the relationship between two quantitative variables was analyzed, the "Spearman rho" coefficient was used since the data did not meet the normal distribution conditions.

RESULTS

The receiver operating characteristic (ROC) analysis conducted to forecast polymerase chain reaction (PCR) positivity did not yield any statistically significant findings in the 4C, Priest, and PSI tests (p>0.005). In the context of the same subject, it has been observed that the evaluation of the superiority of 4C, Priest, and PSI can be conducted interchangeably, as there is no statistically significant distinction among them.

In the statistical analysis conducted to predict mortality, the area under the curve (AUC) for 4C was determined to be 0.805 (80.5%), which was found to be statistically significant with a p-value of less than 0.001. The aforementioned value demonstrated a robustness of 80.5% in predicting mortality. The integral of the curve representing PSI yielded a value of 0.802, corresponding to 80.2% of the total area. This result was found to be statistically significant, as indicated by a p-value of less than 0.001. The predictive accuracy of this value in determining Mortality was 80.2%. The integral of the curve representing PSI yielded a value of 0.812 (81.2%), indicating statistical significance with a p-value of less than 0.001. The success rate of this value in predicting mortality was 81.2%. Once again, there was no statistically significant difference observed among the journals in assessing the disparities in the areas under the curve for mortality evaluation (p>0.005).

In the comparative analysis of the 4C, Priest, and PSI tests for predicting mortality, the area under the curve (AUC) for the 4C test was determined to be 0.805 (80.5%). This finding was deemed statistically significant, with a p-value of less than 0.001. The integral of the curve representing PSI yielded a value of 0.802 (80.2%), indicating statistical significance (p<0.001). The calculated value for the area under the curve (AUC) corresponding to PSI was determined to be 0.812, which translates to 81.2% when expressed as a percentage. Furthermore, this result was found to be statistically significant with a p-value of less than 0.001. The data presented in **Table 1** and **Figure 1** demonstrate that all tests achieved a minimum accuracy rate of 80% in predicting Mortality. Nevertheless, upon comparing the tests, it becomes evident that they can be utilized interchangeably, as there is no statistically significant disparity observed among them (p>0.005). The following table, labeled as **Table 1.1**, is presented for reference.

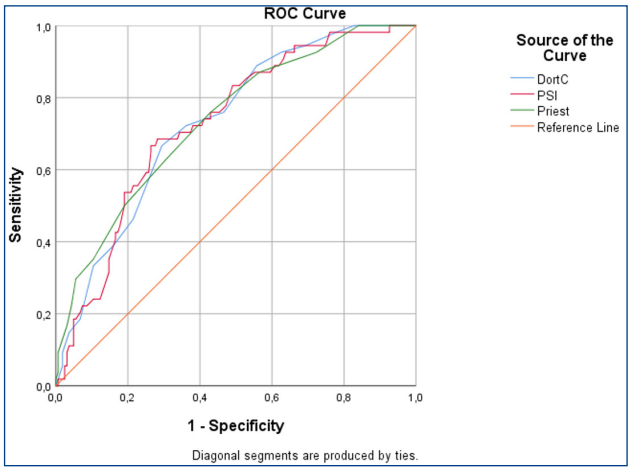

Figure 1: 4C, Priest , PSI ROC analysis for mortality

The study compared the outcomes of patients in the emergency department across three categories: Discharge, Ward, and Intensive care. The results showed that for patients treated in the Ward, values greater than 9.5 on the 4C test were found to be statistically significant (p<0.05). This information can be found in **Table 2** and **Figure 2**. Upon comparing the disparities in the areas under the curve within the same categories, it was observed that the 4C, Priest, and PSI scores exhibited interchangeable usage in both the discharge and ward categories. Furthermore, statistical analysis indicated that there was no significant difference between these scores (p>0.005). In the category of intensive care, there was no significant difference between 4C and PSI (p>0.005), indicating that they could be used interchangeably. However, within the same category, there was a statistically significant difference between 4C and Priest, as well as between PSI and Priest (p<0.005). This suggests that 4C and PSI cannot be used interchangeably with Priest in the context of intensive care (see **Table 2.1**).

Table 1: Comparison of 4C, Priest , PSI for mortality prediction

	Area under the curve (AUC)	std . Mistake	p	Area under the curve (AUC) 95% Confidence limits		Sensitivity	Selectivity	Limits
				lower limit	upper limit			
4C	0.805	0.037	<0.001	0.662	0.805	72.41	64.97	>8
PSI	0.802	0.037	<0.001	0.655	0.802	67.24	73.45	>102
Priest	0.812	0.038	<0.001	0.663	0.812	63.79	69.49	>6

Table 1.1: Comparison of Differences in Areas Under the Curve

	Test Value		Differences in Area Under the Curve	Standard Error (Difference)	Area under the curve (AUC) 95% Confidence limits	
	z	p			lower limit	upper limit
4C - PSI	0.182	0.856	0.005	0.268	-0.044	0.053
4C - Priest	0.117	0.907	-0.004	0.270	-0.074	0.065
PSI - Priest	0.209	0.835	-0.009	0.273	-0.090	0.073

Table 2: Comparison of 4C, Priest , PSI by Emergency Department Outcome Categories

	Area under the curve (AUC)	std . Mistake	p	Area under the curve (AUC) 95% Confidence limits		Sensitivity	Selectivity	Limits
				lower limit	upper limit			
Discharge								
4C	0.726	0.192	0.286	0.350	1,000	50.0	48.8	-
PSI	0.573	0.255	0.729	0.074	1,000	50.0	43.00	-
Priest	0.604	0.111	0.624	0.386	0.821	50.0	43.9	-
Service								
4C	0.737	0.048	0.000	0.643	0.831	65.0	72.00	>9.5
PSI	0.740	0.050	0.000	0.642	0.837	88.0	32.0	-
Priest	0.634	0.057	0.027	0.522	0.747	89.0	39.0	-
Intensive care								
4C	0.426	0.098	0.449	0.234	0.617	45.0	33.0	-
PSI	0.350	0.092	0.126	0.170	0.530	40.9	33.3	-
Priest	0.600	0.101	0.307	0.402	0.798	95.5	26.7	-

Table 2.1: Comparison of Differences in Areas Under the Curve

	Test Value		Differences in Area Under the Curve	Standard Error (Difference)	Area under the curve (AUC) 95% Confidence limits	
	z	p			lower limit	upper limit
Discharge						
4C - PSI	1,546	0.122	0.152	0.659	-0.041	0.346
4C - Priest	0.796	0.426	0.122	0.577	-0.178	0.422
PSI - Priest	0.125	0.901	-0.030	0.635	-0.509	0.448
Service						
4C - PSI	0.063	0.950	-0.003	0.309	-0.083	0.078
4C - Priest	1,944	0.052	0.103	0.321	-0.001	0.206
PSI - Priest	1,548	0.122	0.105	0.326	-0.028	0.238
Intensive care						
4C - PSI	1,033	0.302	0.076	0.423	-0.068	0.220
4C - Priest	2,522	0.012	-0.174	0.432	-0.310	-0.039
PSI - Priest	2,341	0.019	-0.250	0.434	-0.459	-0.041

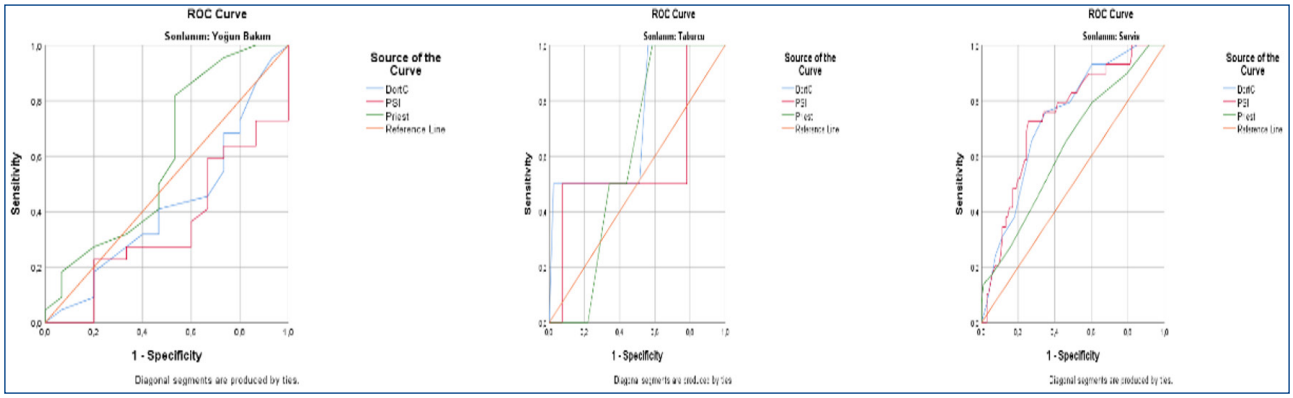

Figure 2: Emergency department outcome 4C, Priest , PSI ROC analysis by categories

A comparative analysis was conducted to examine the significance of the 4C, Priest, and PSI tests in the context of treatment categories administered within the emergency department. Specifically, the study focused on patients who required oxygen and those who did not, as well as patients who necessitated non-invasive ventilation (NIV) and those who were intubated. The receiver operating characteristic (ROC) analysis demonstrated that the three tests yielded statistically significant outcomes among patients who did not require oxygen ($p<0.05$). In the cohort of patients who did not require supplemental oxygen, the threshold value for a 4C score was determined to be greater than 7.5. Similarly, for the PSI score, the cutoff value was found to be above 102.5, while for the Priest score, it was identified as exceeding 4.5. In patients who required oxygen, the threshold values for 4C were greater than 9.5, for PSI were greater than 106.5, and for Priest were greater than 6.5 (refer to **Table 3** and **Figure 3**). When examining the disparities in the areas under the curve,

Table 3: 4C, Priest , PSI Comparison (ROC) According to Treatment Categories Applied in the Emergency Department

	Area under the curve (AUC)	std . Mistake	p	Area under the curve (AUC) 95% Confidence limits		Sensitivity	Selectivity	Limits
				lower limit	upper limit			
not needing oxygen								
4C	0.753	0.078	0.015	0.600	0.905	66.7	65.6	>7.5
PSI	0.743	0.095	0.019	0.557	0.929	77.8	81.3	>102.5
Priest	0.710	0.078	0.042	0.556	0.864	66.7	67.2	>4.5
needing O2								
4C	0.717	0.047	<0.001	0.626	0.808	69.2	67.4	>9.5
PSI	0.710	0.047	<0.001	0.618	0.802	64.1	66.9	>106.5
Priest	0.721	0.049	<0.001	0.625	0.816	74.4	58.7	>6.5
NIV								
4C	0.333	0.204	0.505	0.000	0.733	50.0	16.7	-
PSI	0.500	0.354	1,000	0.000	1,000	50.0	16.7	-
Priest	0.458	0.331	0.868	0.000	1,000	50.0	16.7	-
intubated								
4C	0.875	0.177	0.289	0.529	1,000	1.0	0.0	-
PSI	0.750	0.217	0.480	0.326	1,000	1.0	0.0	-
Priest	0.750	0.217	0.480	0.326	1,000	1.0	0.0	-

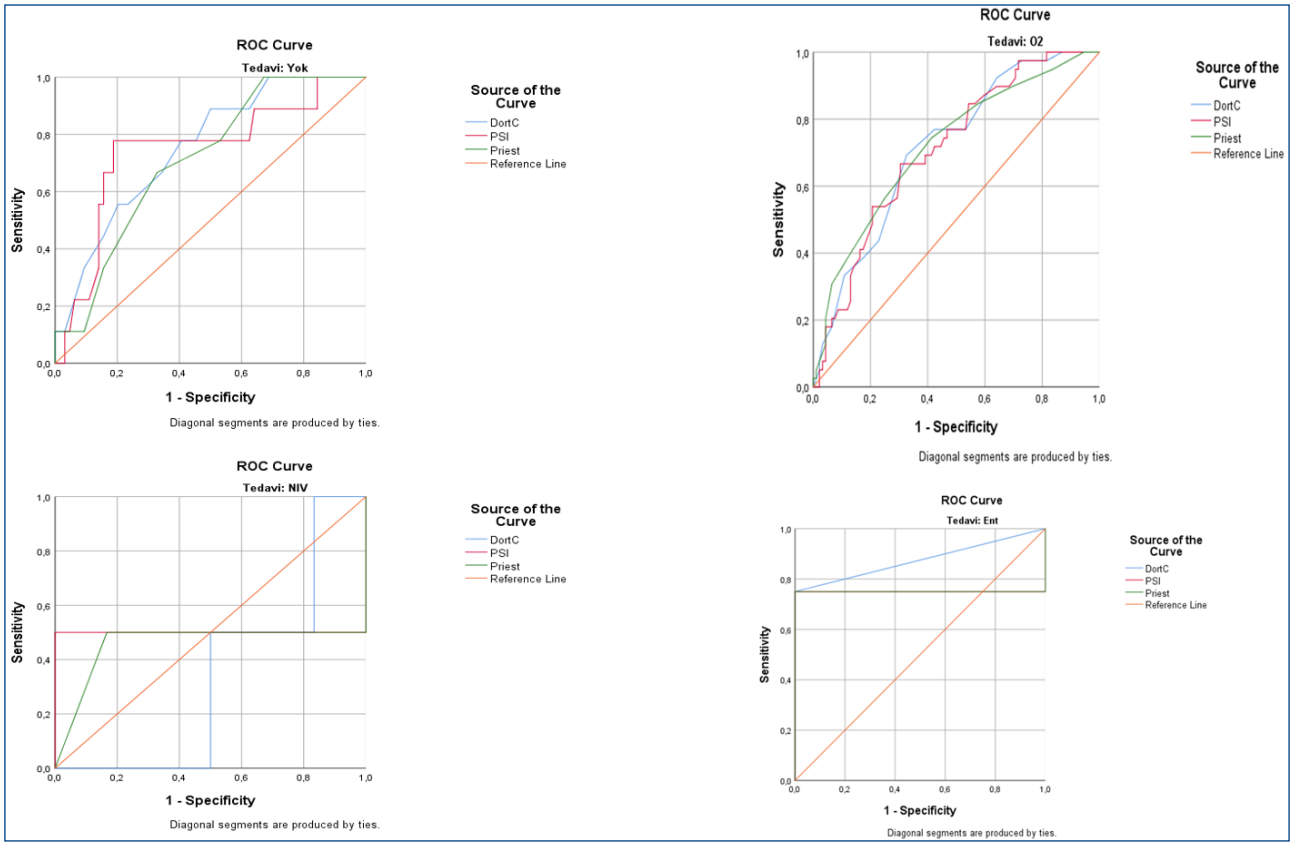

Figure 3. 4C, Priest , PSI ROC analysis by Mortality

it was observed that the scores of 4C, Priest, and PSI exhibited similar patterns in the patient groups who were not administered oxygen support, as well as those who received oxygen support through methods such as O2, NIMV, and IMV in the emergency department. Nevertheless, there was no statistically significant difference observed between them, with a p-value greater than 0.005.

DISCUSSION

In this study, we aimed to evaluate the effectiveness of two clinical severity scoring systems, PRIEST COVID-19 Clinical Severity Score and 4C Mortality Score for COVID-19, in predicting Mortality and disease severity in patients admitted to the emergency department with COVID-19. They compared these scoring systems with the well-established Pneumonia Severity Index (PSI).

In previous studies, Priest was compared with qsofa, sofa, and curb65, and Priest was found to be more specific for covid 19 than these other parameters (10). None of the tested scoring systems in this study, including PRIEST, 4C, and PSI, demonstrated statistically significant predictive power for PCR positivity. This finding aligns with previous research highlighting the limitations of clinical scoring systems in diagnosing COVID-19 infection. Instead, diagnostic tests such as PCR and antigen testing remain the gold standard for confirming COVID-19 cases (11).

The original literature on the 4C mortality score reported that low-, intermediate-, high-, and very high-risk groups mortality rates were 1.2%, 9.9%, 31.4%, and 61.5%, respectively (12). One of the pivotal aspects of our study was the evaluation of these scoring systems in predicting Mortality. The 4C Mortality Score and PSI exhibited robust and statistically significant predictive performance for Mortality, with AUCs exceeding 80%. These findings reinforce the utility of these scoring systems in identifying COVID-19 patients at a higher risk of Mortality. Previous research has also indicated the prognostic value of the 4C Mortality Score, which integrates clinical and laboratory data to predict Mortality in hospitalized COVID-19 patients (13).

Interestingly, our study found no statistically significant differences between PRIEST, 4C, and PSI scoring systems in predicting Mortality. This suggests that healthcare providers may choose among these systems based on familiarity and data availability. Such findings align with the notion that multiple scoring systems can be used interchangeably for assessing disease severity in COVID-19 patients, allowing for flexibility in clinical practice (14).

This study also explored the ability of these scoring systems to differentiate between patients requiring discharge, ward care, and intensive care. For patients admitted to the Ward, the 4C score demonstrated significant predictive power, with values greater than 9.5 indicating a need for forward care. This implies that the 4C score may be particularly useful in guiding decisions about appropriate levels of care for COVID-19 patients in hospital settings. Previous research has emphasized the role of clinical scoring systems in resource allocation and patient triage, which aligns with our findings (15).

In our analysis, all three scoring systems exhibited statistically significant results in predicting the need for oxygen support among patients who did not require it. These scores can help identify patients who are less likely to deteriorate and require oxygen therapy or ventilation. These findings corroborate the clinical relevance of these scoring systems in assisting healthcare professionals in patient management decisions (16).

The findings of this study have significant implications for clinical practice. While these scoring systems may not serve as diagnostic tools for COVID-19, they possess robust predictive capabilities for Mortality and differentiating care needs. Healthcare providers can leverage these tools to optimize patient care, allocate resources efficiently, and identify individuals at a higher risk of severe outcomes, ultimately enhancing clinical decision-making during the ongoing COVID-19 pandemic (17).

Limitations

It is essential to acknowledge some limitations of this study. The research was conducted at a single center and covered a specific time frame, which may limit the generalizability of the results. Additionally, the study did not assess the impact of vaccination status or emerging variants, which could affect disease severity.

CONCLUSION

Comparing the PRIEST COVID-19 Clinical Severity Score and the 4C Mortality Score for COVID-19 to the well-established Pneumonia Severity Index (PSI) was the purpose of this study. The findings of this study provide important new information regarding the predictive capabilities of these scores. Although it is possible that these scoring systems are not appropriate for diagnosing COVID-19, they do demonstrate strong predictive power for mortality and the differentiation of care requirements. In the ongoing battle against the COVID-19 pandemic, medical professionals can put these tools to use to improve the quality of care they provide to patients, make more effective use of the resources at their disposal, and identify individuals who are at a greater risk of experiencing severe outcomes.

ETHICAL DECLARATIONS

Ethics Committee Approval: The study was carried out with the permission of Izmir Katip Çelebi University Ethics Committee (Date: 24.06.2021, Decision No: 0296).

Informed Consent: The mothers were first informed about the study and then signed written consent forms.

Referee Evaluation Process: Externally peer-reviewed.

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

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

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