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Clinical Outcomes of Adults Admitted with COVID-19 at the University Teaching Hospital of Butare, Rwanda, and Validation of the Universal Vital Assessment (UVA) Mortality Risk Score

Stefano Alberto Rinaldi[1]*, Giovanni Marco Bassetti[1], Federica Laura Conti[1]

[1]Department of Management and Technology, SDA Bocconi School of Management, Bocconi University, Milan, Italy.

*E-mail ✉ s.rinaldi.bocconi@gmail.com

Abstract

Limited information exists on the clinical courses of COVID-19 cases in low-resource nations, such as Rwanda. Therefore, the objectives of this investigation were to evaluate 1) the clinical results for individuals hospitalized due to COVID-19 in Rwanda, and 2) the effectiveness of the Universal Vital Assessment (UVA) scoring system in forecasting death among these cases, in contrast to the sequential organ failure assessment (SOFA) and quick SOFA (qSOFA) systems. A retrospective analysis was performed on adults aged 18 years or older who were admitted with confirmed SARS-CoV-2 infection to the University Teaching Hospital of Butare (CHUB) in Rwanda between April 2021 and January 2022. UVA, SOFA, and qSOFA scores were computed for all subjects, and the area under the receiver operating characteristic curve (AUC) was assessed for each. Logistic regression models identified factors linked to fatal outcomes. Among the 150 enrolled cases, 83 (55%) were women, with a median age (interquartile range) of 61 (43–73) years. The typical duration of hospitalization (interquartile range) was 6 (3–10) days. Respiratory compromise affected 69 (46%) patients, of whom 34 (23%) developed acute respiratory distress syndrome (ARDS). In-hospital mortality reached 44%. Independent predictors of death comprised acute kidney injury (adjusted odds ratio [aOR] 7.99, 95% confidence interval [CI] 1.47–43.22, p = 0.016), critical COVID-19 illness (aOR 3.42, 95% CI 1.06–11.01, p = 0.039), and UVA score exceeding 4 (aOR 7.15, 95% CI 1.56–32.79, p = 0.011). The AUC values were 0.86 (95% CI 0.79–0.92) for UVA, 0.81 (95% CI 0.74–0.88) for qSOFA, and 0.84 (95% CI 0.78–0.91) for SOFA, showing no significant differences among them. Using a UVA threshold of >4, sensitivity was 0.58, specificity 0.93, positive predictive value 0.86, and negative predictive value 0.74 for predicting death. Individuals admitted to CHUB with COVID-19 experienced substantial mortality rates, effectively forecasted using the UVA system. Applying the UVA score for COVID-19 patients in resource-constrained settings could support healthcare providers in prioritization and treatment planning.

Keywords: COVID-19, UVA, Mortality risk, Rwanda

Introduction

The illness known as coronavirus disease 2019 (COVID-19), triggered by the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), manifests in a spectrum from no symptoms or minor respiratory issues to severe lung distress syndrome (ARDS), widespread organ failure, and fatality [1]. In populations without prior immunity, around 20% of affected individuals develop breathing difficulties, and a quarter of those require intensive care unit (ICU) placement [2]. Elements increasing the likelihood of advancing to serious COVID-19 are thoroughly documented in affluent countries, yet comparable insights from sub-Saharan Africa, especially Rwanda, remain scarce [3, 4].

Mortality from advanced COVID-19 is elevated, particularly in older adults and those with preexisting health conditions [5]. Prompt identification and intervention are essential for reducing deaths. Thus,

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recognizing patients at elevated risk upon arrival is vital. This has proven difficult in Rwanda owing to constraints in healthcare infrastructure and personnel [6]. Like many nations, Rwanda initially hospitalized all confirmed COVID-19 cases irrespective of symptom severity during the early pandemic phase. As infections surged, hospitalization priorities shifted to critical illnesses and individuals with conditions predisposing them to worsening disease, directing them to specialized high-dependency units (HDUs) or ICUs. The University Teaching Hospital of Butare (Centre Hospitalier Universitaire de Butare [CHUB]) served as the primary facility managing serious COVID-19 patients in Rwanda's southern and western areas.

In well-equipped environments, the sequential organ failure assessment (SOFA) score, incorporating lab results and physiological parameters, aids in gauging illness severity within ICUs [7]. The more straightforward quick SOFA (qSOFA) was developed for application beyond ICUs and has shown utility in resource-limited contexts [8]. Nevertheless, qSOFA lacks endorsement as a sepsis detection instrument because of inadequate sensitivity and specificity [9]. To improve mortality forecasting for inpatient populations in sub-Saharan Africa (sSA), the Universal Vital Assessment (UVA) score was developed from hospital cohort data across six African nations [10]. Its reliability, based on accessible vital signs, has been confirmed in various African regions, including Rwanda, where it surpassed qSOFA performance [11]. As far as we know, UVA has not yet been tested specifically for COVID-19 patients; however, this practical scoring method for stratifying risk in low-income countries (LICs) could prove valuable and straightforward to apply. Thus, this research sought to assess 1) the results for COVID-19 admissions at CHUB, and 2) how well the UVA score forecasts in-hospital death relative to qSOFA and SOFA.

Materials and Methods

This retrospective cross-sectional investigation involved gathering information from individuals diagnosed with SARS-CoV-2 through a positive polymerase chain reaction or rapid antigen test, either at admission or beforehand, who were placed in the high-dependency unit (HDU) or intensive care unit (ICU) at the University Teaching Hospital of Butare (CHUB) between April 20, 2021, and January 17, 2022. Exclusion applied to cases lacking recorded oxygen saturation (SpO2) in the initial

48 hours after arriving at the emergency department, with no additional data gathered from them (n = 33). Severe COVID-19 was classified by the presence of at least one of these features: 1) SpO2 below 94% on room air, 2) PaO2/FiO2 ratio under 300 mm Hg or SpO2/FiO2 ≤315 mmHg, 3) respiratory rate exceeding 30 breaths per minute, or 4) pulmonary infiltrates covering more than 50% of the chest X-ray area [12]. Respiratory failure was identified as ongoing hypoxemia with SpO2 below 90% (PaO2 ≤50–60 mm Hg) even after administration of supplemental oxygen at 10–15 L/minute. Acute kidney injury (AKI) was diagnosed based on any of: serum creatinine rise of ≥0.3 mg/dl (≥26.5 μmol/l) over 48 hours; serum creatinine elevation to ≥1.5 times the known or assumed baseline within the preceding 7 days; or urine output below 0.5 ml/kg/h for 6 hours [13].

Data collection
Demographic details, clinical history, vital parameters, laboratory findings, and imaging results from the first 48 hours post-admission were retrieved. For every case, SOFA scores were computed applying the Kigali adaptation that incorporates SpO2/FiO2 <315, alongside qSOFA and UVA scores. Missing components in these scoring systems were assigned a value of 0. Subjects were categorized into established risk strata according to UVA scores (<2 indicating low risk, 2–4 medium risk, and >4 high risk) [10]. Recorded treatments included medications administered, modes of respiratory assistance (such as high-flow nasal oxygen, invasive ventilation, or noninvasive ventilation), dialysis, nutritional interventions, and outcomes like duration of hospitalization and death during the hospital stay.

Statistical analysis
No predefined sample size calculation or power assessment was performed, given that this was an exploratory review using a convenience cohort of hospitalized COVID-19 cases. Data were entered via Epidata version 3.1 and analyzed with SPSS version 25 and Python version 3.12.4. Categorical data were presented as counts and proportions, while continuous data were summarized using medians and interquartile ranges (IQR). Distribution of continuous variables was evaluated with Kolmogorov-Smirnov and Shapiro-Wilk tests, both showing p-values <0.001 for key outcomes, indicating non-normal distribution. Group comparisons for categorical data employed the chi-square test, and for continuous data, the Mann-Whitney U test was used to

detect median differences. Predictive accuracy for in-hospital death was measured by computing the area under the receiver operating characteristic curve (AUC) for each scoring tool, with pairwise comparisons via the DeLong test. Multivariable logistic regression incorporated factors with p<0.25 from chi-square analyses, along with adjustments for age, qSOFA, and UVA scores; calibration curves were generated for the scores. Additional sensitivity evaluations involved calibration plots derived from Platt scaling, isotonic regression, and random forest methods. The threshold for statistical significance was p<0.05.

Ethical considerations
Approval for the study, including a consent waiver, was granted by the CHUB Institutional Research Board and the College of Medicine and Health Sciences Research Ethics Committee (#REC/UTHB/088/2022). Data access for research occurred from April 4 to 15, 2022. During collection, DFG and TT could view potentially identifying details, but these were not retained or available for analysis. All analyses utilized solely anonymized data.

Results and Discussion

Among the 150 enrolled individuals, 52 (35%) presented with mild or moderate COVID-19, whereas 98 (65%) had severe disease **(Figure 1)**. The overall median (IQR) age was 61 (43–73) years. Those with severe illness had a median (IQR) age of 64 (51–75) years, in contrast to 50 (38–69) years among those with milder forms (p = 0.008). The frequencies of hypertension and diabetes mellitus were comparable between the severe and mild/moderate groups **(Table 1)**. Individuals with severe COVID-19 exhibited a median (IQR) time from symptom onset to medical consultation of 169 (96–192) hours, versus 108 (48–192) hours for those with mild to moderate disease (p = 0.08).
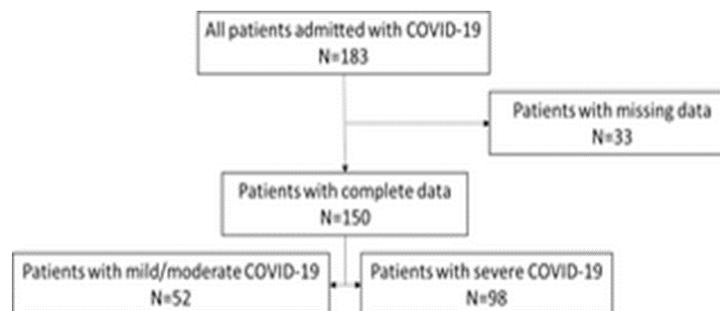
Figure 1. Study flowchart illustrating patient selection for the analysis of clinical outcomes among individuals admitted with COVID-19 to CHUB between May and October 2021.

Table 1. Demographic and clinical characteristics of study participants with COVID-19 at the time of admission to CHUB, May through October 2021

Characteristic	Severe COVID-19 *(N = 98)	Mild to moderate COVID-19* (N = 52)	Missingness N (%)
Demographics			
Age (years)	64 (51–75)	50 (38–69)	0 (0)
Female sex	56 (57)	27 (52)	0 (0)
Time from symptom onset to admission (hours)	169 (96–192)	108 (48–168)	19 (13)
Comorbidities			
Living with HIV	4 (4)	1 (2)	0 (0)
Diagnosed with tuberculosis	1 (1)	0 (0)	0 (0)
Hypertension	24 (24)	12 (23)	0 (0)
Diabetes mellitus	8 (8)	7 (13)	0 (0)
Liver disease	3 (3)	1 (2)	0 (0)
Respiratory symptoms			
Cough	71 (72)	29 (56)	0 (0)
Shortness of breath	65 (66)	17 (33)	0 (0)

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Chest pain	65 (66)	17 (33)	0 (0)
Hemoptysis	4 (4)	0 (0)	0 (0)
Sore throat	1 (1)	0 (0)	0 (0)
Gastrointestinal symptoms			
Vomiting	6 (6)	5 (10)	0 (0)
Abdominal pain	5 (5)	7 (13)	0 (0)
Diarrhea	3 (3)	3 (6)	0 (0)
Nausea	3 (3)	3 (6)	0 (0)
Anorexia	3 (3)	9 (17)	0 (0)
Central nervous system symptoms			
Altered mental status	18 (18)	2 (4)	0 (0)
Headache	12 (12)	12 (23)	0 (0)
Seizures	5 (5)	1 (2)	0 (0)
Agitation	3 (3)	1 (2)	0 (0)
Dizziness	2 (2)	1 (2)	0 (0)
Other symptoms			
Weakness	33 (34)	27 (52)	0 (0)
Rhinorrhea	9 (9)	1 (2)	0 (0)
Chills	2 (2)	0 (0)	0 (0)
Vital signs			
Temperature (°C)	37.6 (36.6–38.7)	37.2 (36.2–38.8)	22 (15)
Respiratory rate ≥30 cycles/minute	35 (36)	0 (0)	0 (0)
Heart rate ≥120 beats/minute	21 (21)	3 (6)	0 (0)
Systolic blood pressure <90 mmHg	10 (10)	3 (6)	0 (0)
Glasgow coma scale score <15	42 (43)	6 (12)	0 (0)
Laboratory values			
Lymphocytes (×10⁹/L)	0.91 (0.62–1.60)	1.2 (0.9–1.94)	16 (11)
Hemoglobin (g/dL)	13.5 (11.8–15.2)	13.0 (12–15)	15 (10)
Creatinine (μmol/L)	77.8 (60.1–119.1)	70.2 (60.8–87.6)	17 (13)
Sodium (mEq/L)	138 (132–142)	137 (134–139)	27 (18)
Alanine transaminase (IU/L)	39 (19–71)	27 (14–43)	27 (18)
Risk scores			
SOFA score	3 (3–6)	1 (0–2)	0 (0)
qSOFA score <2	57 (58)	49 (94)	0 (0)
qSOFA score ≥2	41 (93)	3 (7)	0 (0)
UVA score	3.5 (2–6)	0 (0–0)	0 (0)
UVA score <2	15 (15)	41 (79)	0 (0)
UVA score 2–4	40 (41)	10 (19)	0 (0)
UVA score >4	43 (44)	1 (2)	0 (0)

*Values are expressed as n (%) or median (interquartile range).

Individuals hospitalized with critical COVID-19 illness exhibited a higher prevalence of dyspnea, thoracic discomfort, and impaired consciousness relative to those with less severe forms **(Table 1)**. Among critically ill patients, the median (IQR) UVA score reached 3.5 (2–6), in contrast to 0 (0–0) in the less severe cohort (p<0.001). Likewise, the median (IQR) SOFA score was elevated at 3 (3–6) in critical cases versus 1 (0–2) in milder ones (p<0.001).

Corticosteroid therapy with dexamethasone was provided universally. Antiviral treatment using favipiravir was utilized in 87 patients (58%), while immunosuppressive therapy with tocilizumab was employed in 8 individuals (5%). Self-proning while awake was excluded from routine management protocols for COVID-19 at CHUB and was neither systematically implemented nor documented.

In the subgroup of 98 critically ill patients, respiratory insufficiency emerged in 61 (62%), acute lung injury consistent with ARDS in 34 (34%), and circulatory collapse due to sepsis in 9 (9%). The average length of

inpatient stay remained consistent at 6 days across both illness severity categories.

A total of 66 patients (44%) succumbed to the illness. The proportion of fatal outcomes was significantly greater among those with critical disease (61%) compared to the less severe group (12%) (odds ratio 12.10, 95% CI 4.71–31.07, p<0.001) **(Table 2)**.

Table 2. Association of clinical and socio-demographic characteristics with mortality among patients with COVID-19 admitted to CHUB, May through October 2021.

Characteristic	Survived (n = 84)	Died (n = 66)	Odds Ratio	95% CI	P value	Adjusted Odds Ratio	Adjusted 95% CI	Adjusted P value
Age >65 years	27 (32)	34 (52)	2.72	0.91–8.12	0.071	—	—	—
Female sex	45 (54)	38 (58)	1.07	0.62–1.84	0.058	—	—	—
Hypertension	17 (20)	19 (29)	1.59	0.75–3.38	0.23	—	—	—
Diabetes mellitus	10 (12)	14 (21)	1.52	0.52–4.42	0.45	—	—	—
Living with HIV	2 (2)	3 (4)	0.51	0.08–3.16	0.65	—	—	—
Tuberculosis	0 (0)	1 (1)	0.26	0.01–6.45	0.44	—	—	—
ARDS	8 (10)	22 (33)	2.55	1.16–5.59	0.020	—	—	—
Acute kidney injury	2 (2)	19 (29)	16.57	3.69–74.3	<0.001	7.99	1.47–43.22	0.016
Severe COVID-19	38 (45)	60 (91)	12.10	4.71–31.07	<0.001	3.42	1.06–11.01	0.039
qSOFA ≥2	7 (8)	37 (56)	11.0	4.34–27.8	<0.001	3.05	0.87–10.64	0.08
UVA score <2	50 (60)	6 (9)	Reference	—	—	Reference	—	—
UVA score 2–4	28 (33)	22 (33)	6.55	2.37–18.05	<0.001	2.79	0.87–8.95	0.085
UVA score >4	6 (7)	38 (58)	52.5	15.77–176.6	<0.001	7.15	1.56–32.79	0.011

Mortality differed markedly across key clinical subgroups. Among patients with a qSOFA score of at least 2, 37 of 44 individuals (84%) died, whereas deaths occurred in only 29 of 106 patients (27%) with qSOFA scores below 2, corresponding to an odds ratio (OR) of 11.0 (95 percent CI 4.34–27.8, p < 0.001). Patients who developed ARDS also experienced higher mortality, with 21 deaths (61%) among 34 affected individuals compared with 45 deaths (38.7%) among 116 patients without ARDS (OR 2.55, 95 percent CI 1.16–5.59, p = 0.020). Acute kidney injury was associated with the greatest mortality risk: 19 of 21 patients (90%) with AKI died, compared with only 2 deaths (9%) among patients without AKI (OR 16.57, 95 percent CI 3.69–74.3, p < 0.001). Similarly, disease severity strongly influenced outcomes, as mortality occurred in 60 of 98 patients (61.22%) with severe COVID-19, compared with 38 of 52 patients (38.78%) presenting with mild to moderate illness (OR 12.10, 95 percent CI 4.71–31.07, p < 0.001). In contrast, no significant differences in mortality were observed based on age, sex, or the presence of underlying medical conditions **(Table 2)**.

When stratified by UVA score, mortality risk increased progressively with higher score categories. Relative to patients with UVA scores below 2, those with scores ranging from 2 to 4 demonstrated a significantly elevated risk of death (OR 5.172, 95 percent CI 1.12–22.33, p = 0.03), while patients with UVA scores exceeding 4 had the highest mortality risk (OR 16.85, 95 percent CI 3.01–94.23, p = 0.001) **(Figure 2 and Table 3)**. Discriminatory performance of the scoring systems was high and comparable, with AUC values of 0.86 (95 percent CI 0.79–0.92) for UVA, 0.81 (95% CI 0.74–0.88) for qSOFA, and 0.84 (95 percent CI 0.78–0.91) for SOFA, and no statistically significant differences among them **(Figure 3)**. Using a UVA threshold of 4 to predict mortality yielded a sensitivity of 0.58, specificity of 0.93, positive predictive value of 0.86, and negative predictive value of 0.74.

In multivariable logistic regression analysis, three factors remained independently associated with in-hospital mortality: a UVA score greater than 4 (adjusted OR [aOR] 7.15, 95 percent CI 1.56–32.79, p = 0.011), the presence of acute kidney injury (aOR 7.99, 95 percent CI 1.47–43.22, p < 0.001), and severe COVID-19 at presentation (aOR 3.42, 95 percent CI 1.06–11.01, p = 0.04) **(Table 2)**. ARDS was not included in the multivariable model because of potential collinearity with severe COVID-19.

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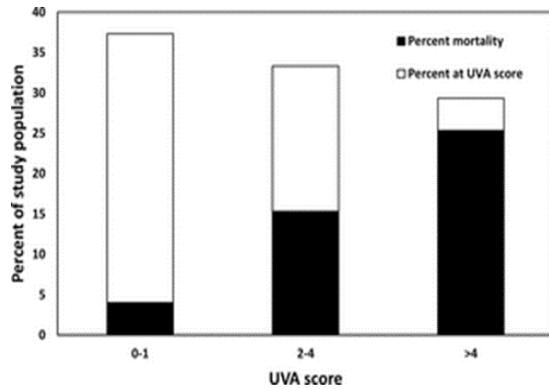
Figure 2. Distribution of UVA risk categories (low 0–1, intermediate 2–4, high >4) and their corresponding case fatality rates among patients admitted with COVID-19 to CHUB between May and October 2021.
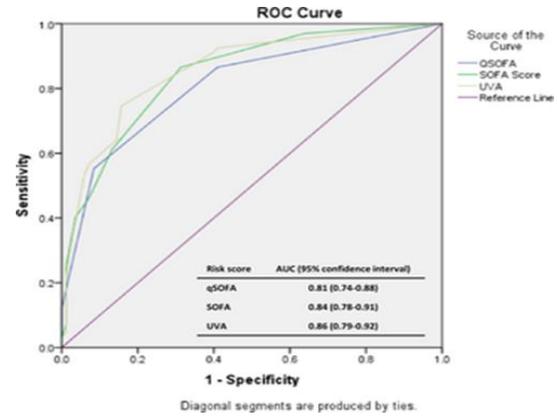
Figure 3. Receiver operating characteristic curves comparing the prognostic performance of qSOFA, SOFA, and UVA risk scores for patients admitted with COVID-19 to CHUB between May and October 2021.

Table 3. Multivariable comparison of UVA score thresholds and their association with in-hospital mortality among patients admitted with COVID-19 to CHUB, May–October 2021

UVA score comparison	Reference category	Odds ratio	95% Confidence interval	P value
UVA score 2–4	UVA score 0–1	7.1	2.6–19.6	<0.0001
UVA score >4	UVA score 0–1	52.8	15.8–176.6	<0.0001
UVA score >4	UVA score 2–4	7.4	2.7–20.7	<0.0001

The results of this investigation revealed that individuals hospitalized for COVID-19 experienced an elevated in-hospital mortality rate of 44%, rising to 61% among those presenting with severe disease upon admission. Key predictors independently linked to death were acute kidney injury (AKI), severe COVID-19 classification, and a UVA score exceeding 4. Both the UVA and qSOFA scoring systems demonstrated strong predictive accuracy for mortality outcomes, comparable to that of the SOFA score, suggesting that UVA and qSOFA could serve as practical tools for stratifying risk in hospitalized COVID-19 patients across Rwanda.

Although age showed a trend toward being higher in cases of severe COVID-19 and in fatal outcomes, this difference lacked statistical significance, possibly reflecting a policy of admitting mostly older individuals irrespective of initial disease severity to facilitate vigilant observation and timely intervention in case of deterioration. This observation is consistent with earlier cohort investigations and a comprehensive review highlighting that older age correlates with greater symptom intensity and elevated complication risks in COVID-19 cases [14, 15]. Similarly, research conducted in Uganda during 2021 identified age of 50 years or older

as a factor linked to in-hospital death from any cause [16]. In the context of alveolar injury, advancing age is associated with heightened expression of Angiotensin-Converting Enzyme-2 (ACE-2), the entry point for the SARS-CoV-2 spike protein [17]. Poorer prognosis in older patients can be attributed to both direct viral effects causing lung damage and indirect effects reducing physiologic resilience, resulting in amplified inflammation, cellular demise, and eventual respiratory compromise. Strategies to block ACE-2 activity might help alleviate SARS-CoV-2-related lung pathology leading to acute injury and severe pneumonitis [18, 19]. Patients who succumbed to COVID-19 in this cohort exhibited higher rates of hypertension and diabetes compared to survivors, though these differences did not reach statistical significance, probably owing to the limited sample size; nevertheless, such comorbidities are frequently tied to more serious COVID-19 presentations [20]. A 2020 Ugandan analysis noted that hypertension, diabetes, and increased body mass index were prevalent among hospitalized COVID-19 individuals [21]. The subsequent 2021 Ugandan investigation reported that the presence of any comorbidity correlated with in-hospital death [16]. Another Rwandan study from 2021 indicated

that severe COVID-19 was related to patient age and comorbidity burden, with individuals over 60 years and those aged 51–60 facing 12-fold and 7-fold higher risks, respectively, versus those under 30, while two comorbidities doubled the likelihood of severe disease relative to none [22]. In a large-scale prospective cohort spanning 10 African nations involving COVID-19 patients, independent mortality predictors encompassed older age, HIV/AIDS, diabetes, chronic liver conditions, and renal disease [4].

The observed in-hospital mortality of 44% overall and 61% in severe cases was notably high, mirroring the 41% rate reported in a broad African prospective study of COVID-19 patients requiring high-dependency or intensive care [4]. Dyspnea and chest discomfort indicative of respiratory compromise emerged as the dominant presenting features in severe cases here. A meta-analysis encompassing 4499 African COVID-19 patients identified fever (43%), cough (33%), dyspnea (17%), and headache (11%) as typical symptoms [23]. Issues such as AKI and acute respiratory distress syndrome (ARDS) stood out as independent mortality contributors, underscoring substantial illness burden and potential constraints in advanced supportive care like dialysis or ventilation [4, 24].

Patients with severe COVID-19 displayed elevated UVA, qSOFA, and SOFA values relative to those with milder forms. The UVA tool achieved solid predictive performance with an AUC of 0.85. As the initial application of UVA in COVID-19 contexts, this compares to prior reports on NEWS2 yielding AUCs of 0.71, 0.77, and 0.87 across UK, South African, and Italian cohorts [25–27]. Although tools like SOFA and SAPS II aid in evaluating organ dysfunction in COVID-19, they depend on lab tests often unavailable in low-income countries [28]. Given this, the UVA approach—relying solely on vital signs, previously shown effective for mortality prediction in Rwandan hospitalized adults regardless of COVID-19 status—may prove valuable in comparable settings [11].

Certain constraints apply to this work. It involved a retrospective review at one Rwandan facility using a non-random sample of admitted COVID-19 cases, influenced by the pandemic's intermittent patterns. Data spanned a defined timeframe amid evolving SARS-CoV-2 strains with variable virulence. Additional confirmation of UVA and alternative scoring systems for COVID-19 mortality forecasting is warranted across diverse sub-Saharan sites. The modest cohort scale could restrict broader

applicability, yet given the scarcity of African-based research on COVID-19 prognosis and scoring tools, these results offer valuable insights and a reference point for subsequent efforts. Moreover, participants likely had minimal prior SARS-CoV-2 immunity, whereas later cases may benefit from vaccine- or infection-derived protection, potentially reducing severity and death rates. Despite this, UVA retained robust mortality discrimination in this COVID-19 group.

Conclusion

In summary, hospitalized COVID-19 patients in Rwanda faced substantial in-hospital death risks. Fatal outcomes were linked to elevated UVA scores, AKI, and severe presentation at CHUB admission. Implementing the UVA score may aid in effectively categorizing risk for hospitalized COVID-19 individuals in Rwanda.

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