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ORIGINAL ARTICLE

Characteristics and clinical outcomes of ICU COVID-19-infected patients, Saudi Arabia, 2021

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ABSTRACT

Background: Although many studies highlighted the clinical features of coronavirus disease (COVID-19), still the clinical profile and associated factors of critically ill patients is limited. Thus, it was aimed to evaluate the clinical characteristics and outcomes of COVID-19-infected patients admitted to the intensive care units (ICU) in the Kingdom of Saudi Arabia (KSA).

Methods: This study was a retrospective noninterventional chart review. Charts and data of all COVID-19-infected patients who required admission to ICU in KSA between August 2020 and April 2021 were obtained from the National Health Observatory Portal of ICU Bed Management System, KSA.

Results: A total of 9,111 patients were included with a mean age of 59.26 ± 16.08. Nearly half of them (*N* = 4,706, 51.7%) had diabetes and 47.1% had hypertension. Totally 3,114 (34.2%) patients received invasive ventilation. Among the studied patients, 81 (0.9%) received extracorporeal membrane oxygenation, while 415 (4.6%) required hemodialysis in the ICU. As for the length of stay (LOS) in the ICU, the mean LOS in days was 11.73 ± 13.36. Having at least one comorbidity (p = <0.001) was seen to be significantly associated with a longer LOS in the ICU. Older age and female gender were significantly associated with mortality (p < 0.001). Mortality incidence was 35.1% (*N* = 3,197).

Conclusion: National Health Observatory Portal analysis revealed that most patients required noninvasive mechanical ventilation. The mortality rate was high, particularly among older individuals with preexisting comorbidities.

Keywords: Coronavirus disease 19, SARS-CoV-2, ICU, comorbidities, intensive care, mortality.

Introduction

The evolution of the severe acute respiratory syndrome coronavirus-2 (SARS-CoV-2) pandemic first took place in Wuhan, China on the 31st of December 2019, spreading across the globe and quickly becoming a worldwide concern. Several countries experienced major health and social economic burdens because of the pandemic. This disease itself is a highly infectious respiratory pathogen and had been subsequently termed 2019 coronavirus disease (COVID-19). According to the World Health Organization, as of July 17th, 2021, the number of infected patients with COVID-19 was 176,531,710 confirmed cases and a total of 3,826,181 associated deaths worldwide, respectively [1-4].

Since the first case of COVID-19 in the Kingdom of Saudi Arabia (KSA) was identified on the 2nd of March [5], the Saudi Ministry of Health raised preparations and precaution standards to control the outbreak as well

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as providing health services to address all medical needs. Moreover, it dedicated more than 25 hospitals with a capacity of 8,800 beds, in addition to 8,000 intensive care unit (ICU) beds, as well as 2,200 isolation beds designated for suspected and quarantined cases [6], which provided no small amount of assistance in providing care for the anticipated large volume of infected patients.

Initial published studies regarding the pandemic focused on evaluating clinical features of COVID-19-infected patients [7]. However, local reports describing clinical characteristics and outcomes of critically ill COVID-19 ICU patients are limited. A previous study conducted in Southern London reported the ICU interventions, clinical features, and outcomes of 85 COVID-19-positive patients. Comorbidities that were considered common were hypertension (51.8%), type 2 diabetes (31.8%), and obesity (48.7%) [8]. In Seattle, a study evaluated the clinical characteristics of 24 critically ill patients admitted to the ICU. More than half of the patients had diabetes mellitus and the majority needed invasive mechanical ventilation [9]. In Italy, Grasselli et al. [10] studied the factors associated with mortality in critically ill patients admitted to the ICU. Among 3,988 patients, 60% had at least one comorbid condition and 87.3% required invasive mechanical ventilation. Overall mortality rate was 25% among 1,581 patients. Risk factors associated with mortality included older age, male gender, and higher fraction inspired oxygen. Similarly, in Singapore, most admitted patients were male and had at least one comorbidity (72.7%), with oxygen-dependent respiratory failure being the most common indication for ICU admission and overall mortality rate of 9.1% [11].

The impact of COVID-19 pandemic resulted in detrimental outcomes on the healthcare system in several countries and their socioeconomic status. Although many studies highlighted the clinical features of COVID-19, but studies describing the clinical profile and associated factors of critically ill ICU patients are limited. Better characterization of critically ill patients is crucial to direct care resources allocation, utilization, and understanding the disease within the local context. Therefore, it was aimed to evaluate the clinical characteristics and determine the mortality risk factors, factors associated with receiving invasive ventilation, renal replacement therapy (RRT), length of stay (LOS), and outcomes of COVID-19-infected patients admitted to the ICU in KSA.

Materials and Methods

The study was a retrospective noninterventional chart review. The study was conducted by reviewing charts and data of all COVID-19-infected patients who required admission to ICU in KSA. The data were obtained from the National Health Observatory Portal, KSA, BMS-COVID list. The portal operates under the supervision of the Ministry of Health, in cooperation with the departments of the Ministry and Health departments in all regions of the KSA. Only hospitalized patients diagnosed by positive tests of real-time polymerase chain reaction for SARS-CoV-2 and required admission to ICU were included in this study. Patients were retrospectively analyzed from August 2020 to April 2021. All cases that were not related to COVID-19 infection were excluded from the study. After data cleaning and exclusion of non-eligible patients, the sample size met the inclusion criteria was found to be 9,111 patients out of 48,036 ICU patients.

The study variables were collected and organized into five main sections: (1) demographic information of the patients such as age, gender, nationality, and hospital region. (2) The status COVID-19 infection is either positive or negative. (3) The presence of comorbidities. (4) ICU profile which consisted of ICU-based interventions, and (5) patients' outcome, the primary outcome was death; other outcomes were still active in the ICU, de-escalated to ward, and transferred to another hospital. The interval from admission to hospital to ICU admission and length of ICU stay were also evaluated.

Data analysis was carried out using Statistical Package for the Social Sciences, 23rd version. Frequency and percentages were used to display categorical variables. Mean and standard deviation were used to present continuous variables. Chi-square test was used to test for the presence of association between categorical variables. Pearson's correlation was used to determine the presence of association between continuous variables. Multivariate logistic regression was used to predict risk factors for mortality in ICU secondary to COVID-19, the following factors were used in the prediction model: gender, receiving extracorporeal membrane oxygenation (ECMO), receiving dialysis in ICU, having diabetes, having hypertension, having chronic kidney disease, having cardiovascular disease, having chronic lung disease, being immune-compromised, being age of 65 years or older, having severe obesity, having liver disease, and having a hemoglobin disease. Omnibus test and Hosmer and Lemeshow test were used to check model's fitness-of-good. Level of significance was set at 0.05.

Results

A total of 9,111 patients were included in the study. The mean age of patients was 59.26 ± 16.08. As for gender, 5,976 (65.6%) were male and 6,013 (66%) were Saudis. As for the place of residency, 2,526 (27.7%) were from the central region, 3,862 (42.4%) were from the western region, and 338 (3.7%) were from the southern region (Table 1).

Around 2,397 (26.3%) were medically free, 6,714 (73.7%) had at least one comorbidity, and 2,404 (26.4%) were 65 years or older (Figure 1).

Almost 3,114 (34.2%) patients received invasive ventilation and 603 (6.6%) did not need oxygen therapy and was on room air. Among those who received invasive ventilation (mechanical ventilation), 2,963 (32.5%) had endotracheal tube. Among those who received noninvasive ventilation (NIV), 961 (10.5%) had high flow nasal cannula. As for those who received oxygen therapy, 1,397 (15.3%) had face masks. Among the participants, 81 (0.9%) received ECMO, while 415 (4.6%) received RRT (dialysis) in ICU. The mean of the interval from

admission to ICU transfer (in days) was 2.46 ± 6.07. As for the LOS in ICU in days (calculated for those with known outcome: de-escalated to ward/deceased), the mean LOS in days was 11.73 ± 13.36 (Table 2).

Around 4,148 (45.9%) were de-escalated to ward, 3,197 (35.1%) passed away, 1,067 (11.7%) were still in the ICU, and 663 (7.3%) were transferred to another hospital.

As for the factors associated with receiving invasive ventilation, age was significantly associated with receiving invasive ventilation ($p < 0.001$), whereas those who received invasive ventilation were observed to be older compared to those who did not receive invasive ventilation (62.91 ± 15.36 *vs.* 57.36 ± 16.12). Having at least one comorbidity was also seen to be significantly associated with the receiving invasive ventilation ($p < 0.001$). As for the factors associated with receiving ECMO, age was significantly associated with receiving ECMO ($p < 0.001$), whereas those who received ECMO were observed to be younger compared to those who did not receive ECMO (47.72 ± 17.5 *vs.* 59.36 ± 16.03).

Table 1. *Sociodemographic profile of the patients (n = 9,111).*

Demographical characteristics	Frequency (*n*)	Percentage (%)
Age		
Mean	59.26	
Standard deviation	16.08	
Gender		
Male	5,976	65.6
Female	3,135	34.4
Nationality		
Saudi	6,013	66
Non-Saudi	3,098	34
Place of residency		
Central region	2,526	27.70
Western region	3,862	42.40
Eastern region	1,432	15.70
Northern region	953	10.50
Southern region	338	3.70

Having at least one comorbidity was also seen to be significantly associated with lower rates of receiving ECMO ($p = 0.028$) (Table 3).

As for the factors associated with receiving invasive ventilation receiving RRT (dialysis) in ICU, age was significantly associated with receiving dialysis in ICU ($p < 0.001$). Having at least one comorbidity was also seen to be significantly associated with receiving dialysis in ICU ($p = <0.001$). Furthermore, age was significantly associated with LOS in ICU ($p < 0.001$, correlation coefficient = 0.086), reflecting a weak positive relationship between age and LOS. Having at least one comorbidity was also seen to be significantly associated with longer ICU LOS ($p = <0.001$) (Table 4).

Age was significantly associated with outcome ($p < 0.001$), whereas those who passed away were observed to be older compared to those who were de-escalated (64.83 ± 14.86 *vs.* 55.17 ± 15.86). Gender was also significantly associated with outcome ($p < 0.006$), whereas higher rate of females passed away compared to males (45.5% *vs.* 42.2%). Having at least one comorbidity was also seen to be significantly associated with outcome ($p = <0.001$). Number of comorbidities was also significantly associated with outcome ($p < 0.001$), whereas those who passed away has higher mean of comorbidities compared to those who were de-escalated to ward (1.92 ± 1.34 *vs.* 1.39 ± 1.25). Receiving ECMO and receiving dialysis in ICU were both significantly associated with outcome ($p < 0.001$ for both of them respectively), whereas those who received either had significantly higher rate of mortality (Table 5).

The following factors were enrolled in the model: gender, receiving ECMO, receiving dialysis in ICU, having diabetes, having hypertension, having chronic kidney disease, having cardiovascular disease, having chronic lung disease, being immune-compromised, being at age of 65 years or older, having severe obesity, having liver disease, and having a hemoglobin disease. The following factors significantly increased the risk of mortality: receiving ECMO [$p = 0.001$, odds ratio = 2.98 (increase by 198%)], receiving dialysis in ICU [$p < 0.001$, odds ratio

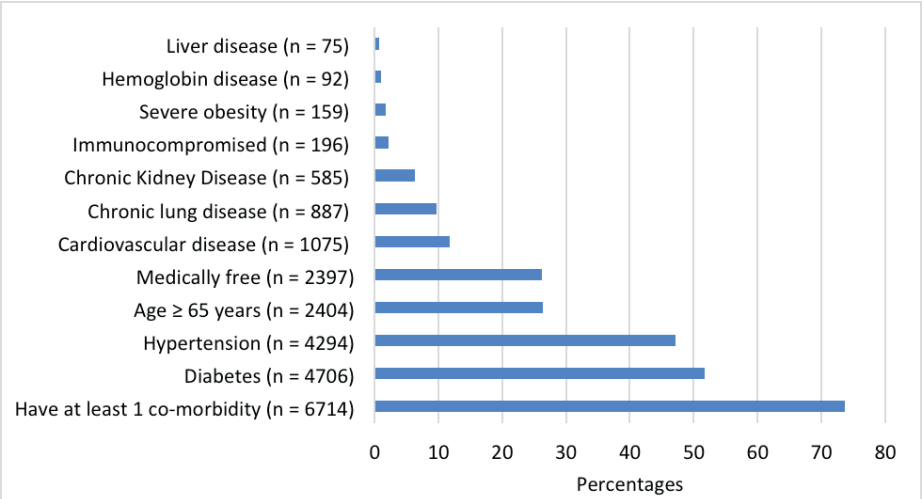

Figure 1. *Medical history of the participants.*

Table 2. *Intervention done for the patients and patients time intervals (n = 9,111).*

Intervention	Frequency (*n*)	Percentage (%)
Invasive ventilation		
Yes	3,114	34.2
No	5,997	65.8
Mechanical ventilation (*n* = 3,114)		
Endotracheal tube	2,963	32.5
Tracheostomy	151	1.7
NIV (*n* = 1,680, 18.44%)		
High flow nasal cannula	961	10.50
Continuous positive airway pressure	200	2.20
Bilevel positive airway pressure	455	5.00
Venturi mask	64	0.70
Oxygen therapy		
Yes	3,714	40.8
No (on room air)	603	6.6
Oxygen therapy type (*n* = 3,714)		
Face mask	1,397	15.3
Nasal cannula	1,173	12.9
Non rebreathing mask	1,144	12.6
ECMO		
Yes	81	0.9
No	9,030	99.1
RRT (Dialysis) in ICU		
Yes	415	4.6
No	8,696	95.4
Plasmapheresis		
Yes	0	0
No	9,111	100
Interval from admission to ICU transfer (in days)		
Mean	2.46	
Standard deviation	6.07	
LOS in ICU (in days) (calculated for those with known outcome: de-escalated to ward/ deceased)		
Mean	11.73	
Standard deviation	13.36	

= 3.33 (increase by 233%)], having diabetes [$p < 0.001$, odds ratio = 1.3 (increase by 30%)], having hypertension [$p = 0.002$, odds ratio = 1.19 (increase by 19%)], having chronic kidney disease [$p = 0.007$, adjusted odds ratio = 1.34 (increase by 34%)], having chronic lung disease [$p = 0.006$, adjusted odds ratio = 1.25 (increase by 25%)], aging 65 years or older [$p < 0.001$, adjusted odds ratio = 2.01 (increase by 101%)], and having a liver disease [$p = 0.046$, adjusted odds ratio = 1.69 (increase by 69%)] (Table 6).

Discussion

In this retrospective, noninterventional chart review study, 9,111 COVID-19 patients who required admission to the ICU were subjected. In this study, the mean age was reported to be 59.26. The mean age was considered higher as compared to a study made at Zhongnan Hospital of Wuhan University in Wuhan, China, showing a mean age of 56 [12]; however, it is lower than what has been observed in a multicentered study previously done in France, Belgium, and Switzerland with a median age of 63 [13].

The incidence of death among COVID-19 ICU patients was found to be 35.1% ($n = 3,197$) in the current study population. Several studies have reported the mortality rate among critically ill COVID1-19 patients admitted to the ICU. The mortality rate in the current cohort was lower than what had been reported in China (61.5%) and Italy (53.4%) [14], and higher compared to Switzerland (31%) [13] and Spain (31%) [15]. Several factors were noticed to be associated with higher mortality risk. Older age was one of the most significant risk factors in the current study patients. Similarly, previous literature generally cited age as an important predictor of mortality [16,17]. Moreover, nearly 74% of the current population had at least one comorbid condition. These results suggested that comorbidities associated with aging, rather than advanced age alone, contribute to a worse prognosis.

Interestingly, even though male patients constituted 65% of the total patients admitted to the ICU, showing similar male predominance compared to other studies [12], mortality was higher in females as compared to males (45.5% *vs.* 42.2%). This was in contrast to the earlier epidemiological observations that even though SARS-CoV-2 affects all age groups, older men with chronic diseases seem to be more severely affected. The first suggestion that men might be disproportionately affected appeared from an early reported study from China [18]. Since then, similar findings were observed in other countries. In Italy, COVID-19-related deaths were higher in men and accounted for about 70% of deaths [19]. Nonetheless, most countries with available data also reported a similar discrepancy in the mortality burden among men, with the largest male-to-female ratios seen in Netherlands, Denmark, Dominican Republic, and Philippines [20]. Current findings suggest that other factors such as lifestyle and sociocultural behaviors are likely to be responsible for these differences, rather than the presumed gender-dependent differences in the immune system, sex hormones, and physiological factors associated with disease severity and overall mortality [19,20].

In the current study, factors associated with the LOS in ICU showed that the presence of at least one comorbidity ($p = <0.001$), diabetes ($p = <0.001$), hypertension ($p = <0.001$), age of 65 years and older ($p = 0.004$), and hemoglobin disease ($p = 0.015$) had a significant association with the LOS. In several studies, diabetes has been shown to be correlated with LOS and hospital admission as well [21,22]. A retrospective cohort study conducted in Fangcang shelter hospital stated that diabetes is the second most prevalent comorbidity with COVID-19 patients; however, diabetes in COVID-19 patients who are not critically ill was not associated with LOS [21]. These findings contradict the current result. The current study analysis was on critical patients in the ICU, and Fangcang's is on non-severe patients. It was

Table 3. *Factors associated with the need of invasive ventilation, ECMO, and RRT in ICU.*

Factor	Need of invasive ventilation	*p*-value	Need of ECMO	*p*-value	Need of dialysis	*p*-value
Gender						
Male	2,009 (33.6%)	0.119	57 (1%)	0.363	268 (4.5%)	0.657
Female	1,105 (35.2%)		24 (0.8%)		147 (4.7%)	
Comorbidity		<0.001*		0.028*		<0.001*
Having at least 1 comorbidity	2,443 (36.4%)		51 (0.8%)		374 (5.6%)	
Medically free	671 (28%)	<0.001*	30 (1.3%)		41 (1.7%)	0.001*
Diabetes				<0.001*		
Yes	1,763 (37.5%)		25 (0.5%)		246 (5.2%)	
No	1,351 (30.7%)		56 (1.3%)		169 (3.8%)	
Hypertension				0.003*		
Yes	1,630 (38%)	<0.001*	25 (0.6%)		271 (6.3%)	<0.001*
No	1,484 (30.8%)		56 (1.2%)		144 (3%)	
Chronic kidney disease				0.316		
Yes	276 (47.2%)	<0.001*	3 (0.5%)		193 (33%)	<0.001*
No	2,838 (33.3%)		78 (0.9%)		222 (2.6%)	
Cardiovascular disease				0.115		
Yes	448 (41.7%)	<0.001*	5 (0.5%)		90 (8.4%)	<0.001*
No	2,666 (33.2%)		76 (0.9%)		325 (4%)	
Chronic lung disease				0.001*		
Yes	286 (32.2%)	0.201	17 (1.9%)		44 (5%)	0.542
No	2,828 (34.4%)		64 (0.8%)		371 (4.5%)	
Immunosuppression				0.082		
Yes	60 (30.6%)	0.287	4 (2%)		10 (5.1%)	0.710
No	3,054 (34.3%)		77 (0.9%)		405 (4.5%)	
Age of 65 years and older				<0.001*		
Yes	1,047 (43.6%)	<0.001*	7 (0.3%)		143 (5.9%)	<0.001*
No	2,067 (30.8%)		74 (1.1%)		272 (4.1%)	
Severe obesity				0.176		
Yes	58 (36.5%)	0.537	3 (1.9%)		8 (5%)	0.771
No	3,056 (34.1%)		78 (0.9%)		407 (4.5%)	
Liver disease				0.681		
Yes	27 (36%)	0.738	1 (1.3%)		8 (10.7%)	0.011*
No	3,087 (34.2%)		80 (0.9%)		407 (4.5%)	
Hemoglobin disease				0.839		
Yes	25 (27.2%)		1 (1.1%)		7 (7.6%)	
No	3,089 (34.2%)	0.155	80 (0.9%)		408 (4.5%)	0.158
Age comparison across needing invasive ventilation			Age comparison across ECMO		Age comparison across Dialysis	
Need intervention	62.91 + 15.36	<0.001*	47.72 + 17.5	<0.001*	61.35 + 15.3	0.007*
Did not need intervention	57.36 + 16.12		59.36 + 16.03		59.16 + 16.11	

* Significant at level 0.05.

noticed that a difference when comparing the current results with studies in China. Females were more likely to have a prolonged LOS than men, and prolonged LOS was observed in patients with chronic kidney disease and chronic lung disease, with significant results [21,22].

The mean interval from admission to ICU transfer (in days) was 2.46 ± 6.07 compared to another study in Washington state it was less than 24 hours [23]. The mean LOS in ICU (in days) (calculated for those with the known outcome: de-escalated to ward/deceased) was 11.73 ± 13.36 in the current study compared to another study of critically ill patients in Wuhan who had died in 28 days. A possible explanation for the shorter interval between hospital admission and ICU admission in the current study is the availability of ICU beds and the continued increase in ICU bed capacity. The Saudi Ministry of Health had recently enhanced various hospitals throughout KSA (more than 2,800 ICU beds within 90 days) [15,24], in contrast to the reported bed crises in other countries [16,25].

Due to the respiratory compromise COVID-19 patients encountered, several modalities have been established

Table 4. *Factors associated with the LOS in ICU.*

Factor	LOS in ICU (in days)		*p*-value
	Mean	Standard deviation	
Patient age (mean, SD)			
Correlation coefficient	0.086		
p-value	<0.001*		
Gender			0.732
Male	11.69	13.04	
Female	11.8	13.95	
Comorbidity			<0.001*
Presence of at least comorbidity	12.24	13.86	
Medically free	10.27	11.68	
Diabetes			<0.001*
Yes	12.46	14.02	
No	10.94	12.55	
Hypertension			<0.001*
Yes	12.35	13.82	
No	11.17	12.91	
Chronic kidney disease			0.232
Yes	12.42	15.84	
No	11.68	13.17	
Cardiovascular disease			0.525
Yes	11.99	15.26	
No	11.69	13.08	
Chronic lung disease			0.265
Yes	12.23	14.25	
No	11.67	13.26	
Immunosuppression			0.469
Yes	12.46	11.77	
No	11.71	13.39	
Age of 65 years and older			0.004*
Yes	12.46	13.64	
No	11.47	13.25	
Severe obesity			0.548
Yes	12.42	12.86	
No	11.72	13.37	
Liver disease			0.477
Yes	12.87	17.31	
No	11.72	13.32	
Hemoglobin disease			0.015*
Yes	15.22	20.36	
No	11.69	13.26	

* Significant at level 0.05.

to ensure adequate ventilation was used, including invasive ventilation with either endotracheal intubation or tracheostomy, NIV, oxygen therapy, and ECMO. The ventilatory management and interventions for the patients are based on the subjective targeted oxygen saturation stated from the latest Saudi Ministry of Health Mechanical Ventilation Protocol for COVID-19 [16,26]. In the current study, more than half of the patients did not require invasive ventilation (65.8%), in contrast to recently reported other ICU patients that required invasive ventilation: 88% (Lombardy, Italy) [14], 71% (Washington State, US) [27], and 47% (Wuhan, China) [12,18]. In the current study, most patients required NIV with a predominance use of high flow nasal cannula (10.5%). Similarly, studies reported a mean of 35% required NIV, with a predominance of high flow nasal oxygenation [19,28]. ECMO has been considered a rescue therapy for severe acute respiratory distress syndrome [29]. Few studies reported the outcomes of ECMO use among those patients. Grasselli et al. [14] reported that 31 out of 52 critically ill individuals admitted to the ICU had died; among the 52 patients, 6 patients received ECMO, and 5 died at 28-days. In the current study, 81 patients received ECMO therapy; on

Table 5. *Factors associated with outcome.*

Factor	Outcome		*p*-value
	Deceased	De-escalated to ward	
Patient age (mean, SD)	**64.83 + 14.68**	**55.17 + 15.86**	**<0.001***
Gender			0.006*
Male	2,037 (42.2%)	2,795 (57.8%)	
Female	1,160 (45.5%)	1,389 (54.5%)	
Comorbidity			<0.001*
Presence of at least comorbidity	2,618 (47.7%)	2,876 (52.3%)	
Medically free	579 (30.7%)	1,308 (69.3%)	
Diabetes			<0.001*
Yes	1,890 (48.7%)	1,994 (51.3%)	
No	1,307 (37.4%)	2,190 (62.6%)	
Hypertension			<0.001*
Yes	1,760 (49.7%)	1,780 (50.3%)	
No	1,437 (37.4%)	2,404 (62.6%)	
Chronic kidney disease			<0.001*
Yes	301 (62.6%)	180 (37.4%)	
No	2,896 (42%)	4,004 (58%)	
Cardiovascular disease			<0.001*
Yes	484 (52.7%)	435 (47.3%)	
No	2,713 (42%)	3,749 (58%)	
Chronic lung disease			0.003*
Yes	360 (48.4%)	384 (51.6%)	
No	2,837 (42.7%)	3,800 (57.3%)	
Immunosuppression			0.184
Yes	78 (48.4%)	83 (51.6%)	
No	3,119 (43.2%)	4,101 (56.8%)	
Age of 65 years and older			<0.001*
Yes	1,135 (58.1%)	819 (41.9%)	
No	2,062 (38%)	3,365 (62%)	
Severe obesity			0.349
Yes	49 (39.2%)	76 (60.8%)	
No	3,148 (43.4%)	4,108 (56.6%)	
Liver disease			0.007*
Yes	40 (59.7%)	27 (40.3%)	
No	3,157 (43.2%)	4,157 (56.8%)	
Hemoglobin disease			0.252
Yes	30 (37%)	51 (63%)	
No	3,167 (43.4%)	4,133 (56.6%)	
Number of comorbidities (mean, SD)	1.92 + 1.34	1.39 + 1.25	<0.001*
ECMO			<0.001*
Yes	34 (70.8%)	14 (29.2%)	
No	3,163 (43.1%)	4,170 (56.9%)	
RRT (Dialysis) in ICU			<0.001*
Yes	261 (75%)	87 (25%)	
No	2,936 (41.7%)	4,097 (58.3%)	

* Significant at level 0.05.

multivariate logistic regression, ECMO was considered a risk factor associated with higher mortality [$p = 0.001$, odds ratio = 2.98 (increase by 198%)]. Given the lack of clinical trials of ECMO therapy on COVID-19, whether SARS-CoV-2-infected patients have benefited from the use of ECMO therapy at this time was not concluded.

This study has several limitations. First, this was a retrospective study, and data were acquired from the National Health Observatory Portal, which has a fixed type of format that is applied for each patient admitted to the ICU. The NHOP is mainly a real-life database made for operational reasons. Thus, other variables such as smoking history, respiratory system compliance,

Table 6. *Multivariate logistic regression (factors predicting mortality).*

Factor	*p*-value	Odds ratio	Confidence Interval	
Gender (Male *vs.* Female)	0.156	0.93	0.84	1.03
ECMO (Yes *vs.* No)	0.001*	2.98	1.55	5.73
RRT (Dialysis) in ICU (Yes *vs.* No)	<0.001*	3.33	2.55	4.35
Diabetes (Yes *vs.* No)	<0.001*	1.30	1.16	1.44
Hypertension (Yes *vs.* No)	0.002*	1.19	1.07	1.33
Chronic kidney disease (Yes *vs.* No)	0.007*	1.34	1.08	1.66
Cardiovascular disease (Yes *vs.* No)	0.181	1.11	0.95	1.28
Chronic lung disease (Yes *vs.* No)	0.006*	1.25	1.07	1.46
Immunosuppression (Yes *vs.* No)	0.512	1.12	0.80	1.55
Age of 65 years and older (Yes *vs.* No)	<0.001*	2.01	1.80	2.25
Severe obesity (Yes *vs.* No)	0.093	0.72	0.50	1.06
Liver disease (Yes *vs.* No)	0.046*	1.69	1.01	2.82
Hemoglobin disease (Yes *vs.* No)	0.217	0.74	0.46	1.20

* Significant at level 0.05.

and medication history could not be assessed. Another significant limitation is that a detailed report of physiological, clinical features, including radiographic data and laboratory predictors related to the outcomes of COVID-19 patients admitted to the ICU could not be provided. Nonetheless, current study permits a preliminary assessment of the clinical course and outcomes of critically ill patients with SARS-CoV-2 infection. Finally, it was hoped that the current findings presented in this study would encourage more extensive studies to investigate the interventions that could improve survival among COVID-19 patients admitted to the ICU.

Conclusion

In this retrospective cohort study of critically ill patients admitted to ICUs in KSA, most patients required noninvasive mechanical ventilation. The mortality rate was high particularly among older individuals with preexisting comorbidities. Further extensive studies are needed to investigate the interventions that could improve the survival rate among critically ill high-risk COVID-19 patients.

List of Abbreviations

COVID-19	Coronavirus disease
ECMO	Extracorporeal membrane oxygenation
ICU	Intensive care unit
KSA	Kingdom of Saudi Arabia
LOS	Length of stay
SARS-CoV-2	Severe acute respiratory syndrome coronavirus-2

Conflict of interest

The authors declare that there is no conflict of interest regarding the publication of this article.

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Consent to participate

Informed consent was obtained from all the participants.

Ethical approval

The Saudi Central Institutional Review Board at the Ministry of Health, KSA, approved this study and waived the need for informed consent from individual patients owing to the retrospective nature of the study with approval number H-01-R-009 and date of approval on March 30, 2021.

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