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Analysis of the Clinical Characteristics of COVID-19 Patient Severity Amongst Saudi Hospital Admission in 2020

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ABSTRACT

Background and aims: Coronavirus Disease 2019 (COVID-19), the infection caused by the SARS-CoV-2 virus, is associated with variable clinical symptoms ranging from asymptomatic to severe manifestations that lead to increased mortality. Some of these abnormalities are linked to hematologic, inflammatory, biochemical and immune biomarkers, in cases with severe forms of the illness compared to mild systemic disease. However, such associations have not been studied in detail in Saudi Arabia. This study was conducted to evaluate these clinical indices in a Saudi population admitted to hospital in Makkah during 2020 with a positive diagnosis of COVID-19, as possible risk factors for COVID-19 related fatality.
Materials and methods: Demographic and biochemical data related to type of admission, hematological indices, liver and renal functions, markers of inflammation and blood gases were collected at the time of patient admission. The variables were then compared between both groups to determine potential risk factors that contribute to COVID-19 fatality.
Results: A total of 315 patients with confirmed COVID-19 infection by PCR and complete final status (recovered or dead) were identified and included in the study. By additional analysis, mean age was significantly higher in deceased patients compared with those who recovered from infection. Moreover, death from COVID-19 infection was significantly more common in patients admitted to ICU compared with ward admission. Patients admitted to ICU had a substantially greater risk of dying from COVID-19 infection (46-fold) compared with ward admission. Contrariwise, higher mean O_2sat was associated with significantly lower odds of death.
Conclusions: Males and non-Saudi residents were more susceptible to acquiring infection during the first wave of COVID-19. Although liver and renal biochemical parameters, haematological indices, and respiratory functions were significantly altered with COVID-19 infection and more pronounced in deceased patients, only ICU admission and low O_2 pressure showed higher risks of death from the infection.

1. Introduction

In December 2019, a novel coronavirus, presently known as Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2), developed in Wuhan, China (Huang *et al*., 2019, Al-Mulla *et al*., 2021). To date, the infection has spread quickly all over the world and was announced a pandemic by the World Health Organization in March 11, 2020. With the number of cases as of now surpassing 100 million, and more than two million fatalities, the virus is considered a serious problem in the world [1, 2]. Coronavirus Disease 2019 (COVID-19), the infection caused by the virus, has a profoundly variable clinical introduction, extending from asymptomatic to severe manifestations leading to increased mortality. The COVID-19 symptoms include malaise, fever, cough, myalgia, dyspnea, cerebral infarction, headache and loss of taste or scent. Most patients encounter mild symptoms, in spite of the fact that a few may experience serious complications, such as acute respiratory distress syndrome (ARDS), hypercoagulation, multiorgan failure and septic shock, which can inevitably lead to death [3-6]. However, the reasons for the variability in disease signs and symptoms are not completely understood. Furthermore, younger age cases appear to have a milder clinical course [7], with poorer prognosis in geriatric and male gender cases. Currently, certain medical conditions, including cardiovascular diseases, chronic kidney disease hypertension, chronic obstructive pulmonary disease and diabetes, are associated with worsening COVID-19 prognosis [8-12]. Indeed, people with diabetes mellitus (DM) are more prone to be infected and are at a greater risk of death and severe complications from COVID-19. And remarkably, there was a parallel trend of increased risk for Severe Acute Respiratory Syndrome (SARS) and Middle Eastern Respiratory Syndrome (MERS) diseases caused by the related beta-coronaviruses, in people with DM [13].

On March the 9th, 2020, the Saudi Ministry of Health had recorded four new patients with COVID-19. However, this figure had increased to 3,717 cases of the disease within a month, with the total number of the active cases standing at 33,515 on June 10, 2020, whilst critical cases were 1,693 between the total active cases [14]. Regarding the foremost newly published Diagnosis and Management Program of 2019 New Coronavirus Pneumonia [12], COVID-19 patients are separated into 3 groups, mild, moderate and severe. Consequentially,

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from laboratory blood analysis, hematological parameters, including lymphopenia, white blood cell (WBC), C-reactive protein (CRP), and biochemical parameters, including creatine kinase (CK), LDH and troponin were found to be related with increased COVID-19 severity [15, 16]. Additionally, numerous research studies have described the clinical features and laboratory variations related to COVID-19 patients ([17-19]. Furthermore, total number of COVID-19 cases are increasing considerably, and admission in intensive care units (ICUs) has developed an important challenge for countries and governments [20]. The disease caused by SARS-CoV-2 infection can also cause serious respiratory disease, which may advance to clinically severe stages, demanding ICU admission and ventilator care [17, 21]. A severe form of the illness has been linked with abnormalities associated with hematological, inflammatory, biochemical and immune biomarkers, compared to groups with mild systemic disease [4, 17, 19, 21-24]. Moreover, there is lack of available data within the Kingdom of Saudi Arabia, especially amongst hospitalized patients, on how these clinical indices may affect disease burden. To this end, this study aimed to investigate the biochemical profiles, haematological indices, liver and renal functions, markers of inflammation and blood gases, among COVID-19 patients admitted to hospital in the Makkah region, who had either recovered or deceased, to determine any association with COVID-19 fatality.

2. Patients and methods

Study design and data collection

This was a retrospective cohort study. All patients with confirmed COVID-19 infection by polymerase chain reaction (PCR) during June, August and October 2020 were recruited from Alawi Tunsi hospital in Makkah. The clinical date at the day of admission was collected for those patients with a listed final status, as either recovered or deceased, at the time of discharge. Patients transferred to a different health facility, or their unclear final status were excluded from the study.

In addition to demographic data, the biochemical data related to the type of admission, haematological indices, liver and renal functions, a marker of inflammation and blood gases were collected at the time of patient admission. The main outcome was recovery or death from COVID-19 infection, and the patients were categorised as recovered or deceased groups. The variables were then compared between both groups to determine the potential risk factors that contribute to COVID-19 fatality.

Statistical analysis

Version 25 of the Statistical Package for the Social Sciences (SPSS; NY, USA) for data analysis. Ordinal and non-continuous variables were analysed to measure frequency, and the results are shown as numbers and percentages and by cross-tabulation followed by the Chi-square (χ^2) test. We also assessed the normality and homogeneity of continuous data by the Kolmogorov and Smirnov, and the Levene tests, respectively. Student's t-test or Mann-Whitney u test were applied to compare between both study groups according to data normality. The results of continuous data are expressed either as mean ± standard deviation (SD) or median with the interquartile range (IQR: 25^{th} – 75^{th} percentiles) according to data normality. Binary logistic regression was done to identify the demographic and biochemical factors associated with death from COVID-19 infection. Statistical significance was considered when P value was < 0.05.

Ethical approval

This study is part of larger multicentre study involving the Western region of Saudi Arabia, and ethical approval was obtained from the Internal Review Board of Security Forces Hospital Makkah (SFHM) (SFHM; # 0432-280621) in Makkah.

3. Results

Demographic characteristics of COVID-19 patients

A total of 315 patients with confirmed COVID-19 infection by PCR alongside a complete final status (recovered or dead) were identified and included in the study. The overall mean age of the 315 patients was 43.2 ± 12.9 years. The numbers of cases were 108 (34.3%) in June, 104 (33%) in August, and 103 (32.7%) in October, and the rates were equal during the three months (P = 0.9). However, the frequencies of males (n = 239; 75.9%) and non-Saudis (n = 176; 55.9%) were significantly higher compared with female (P < 0.0001) and Saudi (P = 0.04) patients. While most of the patients were admitted to Medical ward (n = 203; 64.4%), the remainder were admitted to the intensive care unit (ICU) (n = 112; 35.6%). By additional analysis, the mean of age was significantly higher in the deceased patients compared with those who recovered from the infection (Table 1). Moreover, death from COVID-19 infection was significantly more common in those patients admitted to ICU compared with ward admission (Table 1). However, there was so significant difference between the recovered and deceased group in relation to gender, nationality, month of diagnosis of having a history of diabetes mellitus (Table 1).

Table 1 The frequency of demographic characteristics of the study participants (n = 315) according to demise.

Parameter	COVID-19 positive cases (n = 315; 100%)		P value
	Recovered (n = 284; 90.2%)	*Deceased (n = 31; 9.8%)*	
Mean ± SD of Age (year)	42.3 ± 12.9	50.9 ± 10.5	P < 0.0001
Month of infection June August October	 93 (29.5%) 95 (30.2%) 96 (30.5%)	 15 (4.8%) 9 (2.8%) 7 (2.2%)	0.19
Gender Male Female	 218 (69.2%) 66 (21%)	 21 (6.6%) 10 (3.2%)	0.27
Nationality Saudi Non-Saudi	 128 (40.7%) 156 (49.5%)	 11 (3.5%) 20 (6.3%)	0.3
Admission Ward ICU	 202 (64.1%) 82 (26.1%)	 1 (0.3%) 30 (9.5%)	P < 0.0001
History of diabetes mellitus No Yes	 244 (77.5%) 40 (12.7%)	 24 (7.6%) 7 (2.2%)	0.2

Laboratory biochemical parameters
Haematological indices

As shown in Table 2, the deceased group had significantly lower red blood cells (RBCs) count, haemoglobin (Hb) concentrations, haematocrit value, mean corpuscular volume (MCV), and mean corpuscular haemoglobin (MCH) than the recovered group. The remaining RBCs indices and serum ferritin levels were, however, comparable between both groups (Table 2). Whilst the platelet count was also significantly lower in the deceased group, there were no significant differences between both study groups in the mean platelet volume (MPV), pro-thrombin time (PT), partial thromboplastin time (PTT), and international normalised ratio (INR).

Moreover, the total numbers of WBCs and basophils were similar between the recovered and deceased groups, whilst the neutrophil count was significantly higher in the latter group (Table 2). In contrast, the numbers of lymphocytes, monocytes and eosinophils were markedly higher in the recovered group than the deceased group at the time of admission (Table 2).

Table 2 The mean (±SD) and median (IQR) of haematological indices at admission according to demise in the study participants (n = 315).

Parameter	COVID-19 positive cases (n = 315; 100%)		P value
	Recovered (n = 284; 90.2%)	*Deceased (n = 31; 9.8%)*	
Median (IQR) of serum ferritin (µg/L)	759 (327.3 – 1593.5)	759.1 (308.67 – 1327.0)	0.9
Mean ± SD of RBCs count (10^6/µL)	4.4 ± 0.9	3.6 ± 0.9	< 0.0001
Mean ± SD of Hb (g/dL)	12.1 ± 2.3	10.3 ± 2.5	< 0.0001
Median (IQR) of haematocrit value (%)	37.15 (30.75 – 40.6)	31.6 (25.1 – 35.0)	< 0.0001
Mean ± SD of MCV (fL)	82.7 ± 7.4	85.6 ± 7.5	0.04
Mean ± SD of MCH (pg)	28.2 ± 2.7	29.8 ± 2.7	0.005
Mean ± SD of MCHC (g/dL)	33.6 ± 1.9	33.2 ± 1.7	0.2
Median (IQR) of platelets count (10^3/µL)	269.5 (199.25 – 359)	221 (137 – 300)	0.004
Mean ± SD of MPV (fL)	10.4 ± 1.7	10.7 ± 1.8	0.4
Mean ± SD of PT (sec)	12 ± 2.4	12.2 ± 1.5	0.6
Mean ± SD of PTT (sec)	33.1 ± 9.8	33.9 ± 6.8	0.6
Mean ± SD of INR	1.02 ± 0.2	1.05 ± 0.2	0.4
Median (IQR) of WBCs count (10^6/µL)	8.35 (6.25 – 10.98)	7.8 (6.15 – 12.6)	0.9
Mean ± SD of neutrophil count (10^3/µL)	76.02 ± 14.2	83.02 ± 10.7	0.008
Median (IQR) of lymphocyte count (10^3/µL)	14.15 (6.9 – 22.4)	8.7 (4.6 – 16)	0.02
Median (IQR) of monocyte count (10^3/µL)	5.6 (3.6 – 8.6)	4.1 (3.1 – 6.7)	0.03
Median (IQR) of eosinophil count (10^3/µL)	0.1 (0.0 – 0.8)	0.0 (0.0 – 0.4)	0.01
Median (IQR) of basophil count (10^3/µL)	0.3 (0.1 – 0.5)	0.2 (0.1 – 0.3)	0.07

Markers of systemic inflammation and liver function tests

Regarding the systemic inflammatory markers, the erythrocyte sedimentation rate (ESR) and serum concentrations of lactate dehydrogenase were equal between both study groups (Table 3).

While the serum levels of total and direct bilirubin alongside alkaline phosphatase enzyme were substantially elevated in the decreased group, there was no significant difference between both groups in the serum amounts of alanine transferase (ALT) and aspartate aminotransferase (AST) enzymes. In contrast, the levels of serum total protein and albumin were markedly higher in the recovered group (Table 3).

Table 3 The mean (±SD) and median (IQR) of markers of systemic inflammation and liver function parameters at admission according to demise in the study participants (n = 315).

	Parameter	COVID-19 positive cases (n = 315; 100%)		P value
		Recovered (n = 284; 90.2%)	*Deceased (n = 31; 9.8%)*	
Inflammation	*Median (IQR) of ESR (mm/hour)*	45 (10 – 86)	30 (10 – 70)	0.5
	Mean ± SD of lactate dehydrogenase (U/L)	366.5 ± 168.7	318.2 ± 124.9	0.1
Liver functions	*Median (IQR) of total bilirubin (mg/dL)*	8.04 (5.8 – 13.1)	10.7 (7.7 – 15.6)	0.08
	Median (IQR) of direct bilirubin (mg/dL)	2.77 (1.7 – 4.6)	4 (2.9 – 7.1)	< 0.0001
	Median (IQR) of ALP (U/L)	72 (58 – 96.75)	100 (69 – 175)	0.002
	Median (IQR) of ALT (U/L)	37.5 (25 – 59)	49 (26 – 87)	0.1
	Median (IQR) of AST (U/L)	41.5 (28 – 58)	40 (29 – 74)	0.6
	Median (IQR) of total protein (g/L)	70 (62 – 76)	66 (54.5 – 71)	0.01
	Median (IQR) of albumin (g/L)	25 (21 – 29)	22 (18 – 25)	0.02

P<0.05 statistically significant: results in bold font

Serum electrolytes and renal biochemical parameters

The serum concentrations of sodium and chloride were significantly higher in the deceased, whereas as potassium was equal, compared with the recovered group (Table 4). Additionally, both serum creatinine and blood urea nitrogen (BUN) were also substantially higher in the deceased group relative to the recovered group (Table 4).

Table 4 The mean (±SD) and median (IQR) of serum electrolytes and renal function parameters at admission according to demise in the study participants (n = 315).

	Parameter	COVID-19 positive cases (n = 315; 100%)		P value
		Recovered (n = 284; 90.2%)	*Deceased (n = 31; 9.8%)*	
Electrolytes	*Mean ± SD of sodium (mmol/L)*	137.4 ± 6.8	140.6 ± 4.8	0.009
	Mean ± SD of potassium (mmol/L)	3.86 ± 0.6	3.97 ± 0.8	0.4
	Mean ± SD of chloride (mmol/L)	102.7 ± 7	105.8 ± 5.9	0.02
Renal functions	*Median (IQR) of BUN (mmol/L)*	5.6 (3.7 – 7.7)	8.5 (6.1 – 12.4)	< 0.0001
	Median (IQR) of creatinine (µmol/L)	75.4 (59.4 – 91.3)	84.6 (62.3 – 102.2)	0.03

P<0.05 statistically significant: results in bold font

Blood gases

The deceased group had significantly lower levels of arterial oxygen saturation (O_2sat) and oxygen pressure (pO_2) that concurred with increased carbon dioxide pressure (pCO_2) and blood pH (Table 5). However, the levels of blood HCO_3 were unaffected.

Risk factors associated with death from COVID-19 patients

The multivariate analysis revealed that patients admitted to ICU had a substantially greater risk of dying from COVID-19 infection (46-fold) compared with ward admission (Table 6). In contrast, higher O_2sat was associated with significantly lower odds of death (0.962). All the remaining demographic and biochemical parameters did not correlate with death from COVID-19 (Table 5).

Table 5 The mean (±SD) and median (IQR) of blood gases at admission according to demise in the study participants (n = 315).

Parameter	COVID-19 positive cases (n = 315; 100%)		P value
	Alive (n = 284; 90.2%)	*Deceased (n = 31; 9.8%)*	
Median (IQR) of sO_2 (%)	90.2 (78.4 – 97.2)	64 (43.9 – 82)	< 0.0001
Median (IQR) of pO_2 (KPa)	8 (5.9 – 10.3)	6.2 (4.8 – 8.3)	0.005
Median (IQR) of pCO_2 (KPa)	5.3 (4.3 – 6.5)	3.2 (2.8 – 4.5)	< 0.0001
Mean ± SD of HCO_3 (mEq/L)	22.7 ± 4.1	23.4 ± 5.6	0.3
Mean ± SD of pH	7.36 ± 0.09	7.4 ± 0.06	0.02

P<0.05 statistically significant: results in bold font

Table 6 Predictors of death from COVID-19 infection by binary logistic regression analysis presenting odds ratios and confidence intervals, in the total study participants (n = 315).

Predictors	Death from COVID-19 infection	
	Odds ratio (95%CI)	*P Value*
Admission Ward ICU	 Ref. 46.14 (4.02 - 528.6)	 0.002
Age (Year)	1.018 (0.975 - 1.062)	NS
RBCs count (10^6/µL)	0.42 (0.00016 - 102.94)	NS
Hb (g/dL)	1.184 (0.298 - 4.709)	NS
Haematocrit value (%)	1.243 (0.427 - 3.622)	NS
MCH (pg)	1.018 (0.797 - 1.300)	NS
MCV (fL)	0.806 (0.517 - 1.256)	NS
PLT count (10^3/µL)	0.996 (0.991 - 1.002)	NS
Neutrophil count (10^3/µL)	1.246 (0.751 - 2.068)	NS
Lymphocyte count (10^3/µL)	1.228 (0.743 - 2.032)	NS
Monocyte count (10^3/µL)	1.284 (0.744 - 2.225)	NS
Eosinophil count (10^3/µL)	0.849 (0.300 - 2.402)	NS
Total bilirubin (mg/dL)	1.067 (0.929 - 1.227)	NS
Direct bilirubin (mg/dL)	0.918 (0.712 - 1.183)	NS
ALP (U/L)	1.006 (0.996 - 1.015)	NS
Total protein (g/L)	0.996 (0.712 - 1.183)	NS
Albumin (g/L)	1.039 (0.944 - 1.143)	NS
Sodium (mmol/L)	1.048 (0.869 - 1.265)	NS
Chloride (mmol/L)	1.005 (0.823 - 1.227)	NS
BUN (mmol/L)	1.142 (0.945 - 1.381)	NS
Creatinine (µmol/L)	0.988 (0.969 - 1.006)	NS
sO_2(%)	0.997 (0.990 - 1.005)	NS
pO_2(KPa)	0.962 (0.931 - 0.994)	0.02
pCO_2(KPa)	0.990 (0.975 - 1.005)	NS
pH	4.154 (0.003 - 5583.733)	NS
NS = Non-significant		

P<0.05 statistically significant: results in bold font

4. Discussion

Herein, we retrospectively reviewed the rate of death in 315 patients with PCR-confirmed COVID-19 infection admitted to a single centre in Makkah city during the early wave of the pandemic. Additionally, we also measured the potential demographic factors alongside the laboratory parameters at the time of presentation that were associated with the risk of dying from this highly transmissible infection.

Following the WHO official declaration in March 2020 that COVID-19 is a pandemic, there were 43,766,712 confirmed positive cases and 1,163,459 deaths (2.7%) worldwide by the end of October [25]. In Kingdom of Saudi Arabia (KSA), the infection rate was maximal during June 2020, followed by a gradual decrease and was lowest in October 2020 resulting in 346,047 cumulative cases and 5,348 (1.6%) total deaths [25, 26]. Moreover, a large retrospective study, which included 240,474 cases across the different regions of the KSA, has also reported that COVID-19 infection was more common in males, most of the patients were non-Saudi, and the highest case fatality rates (CFR) were in Jeddah (2.6%) and Makkah (2.16%) relative to the other cities, and death was more common in elders [27]. Other national reports have similarly shown that men and non-Saudis had higher rates of infection, ICU admission occurred in 12-25% of the patients, and elders had a higher risk of dying from the infection [28-30]. Furthermore, the risk of dying from COVID-19 infection increased significantly in patients admitted to ICU [28-32].

Our results revealed that males (75.9%) and non-Saudi residents of KSA (55.9%) were predominant. Additionally, mortality rates were markedly higher in the patients admitted to ICU and deceased patients had significantly higher age compared with those who recovered from the infection. Moreover, the risk of death from COVID-19 increased 46-fold with ICU admission. The present findings support the epidemiological results reported by many of the above-mentioned national reports [27-30].

However, the frequency of cases was equal between the three months (June, August, and October of 2020) study period. Additionally, ICU admission was more prevalent in this study (35.6%) compared with international [31, 32] and national studies [28-30] reported during the same period. The rate of death from COVID-19 infection in the present study was also relatively higher (9.8%) than the WHO and Saudi CDC reports [25, 26].

A possible explanation for the discrepancies between our findings and earlier data could be related to the small sample size included in the current report. Moreover, we only included patients from a single private centre that acted as an auxiliary support facility for the Ministry of Health (MOH) regional hospitals to increase hospitalisation capacity during the pandemic [33-35]. We were also unable to include many of the admitted patients during the study period since they were transferred to different hospitals during their illness and prior to reaching a final clinical outcome (recovery vs. death). Hence, future studies should either obtain the data from the Saudi MOH registry and/or focus on major governmental hospitals to achieve a better follow-up of cases. Additionally, a multicentre approach could be more precise in revealing the prevalence of death from COVID-19, since ours and several earlier single-centre reports demonstrated higher mortality rates than those reported by multicentre studies [28-30].

Prior studies from KSA [29, 36-38] and other countries [39-41] revealed higher rates of anaemia in patients with COVID-19. Furthermore, the abnormal RBCs indices were more pronounced in patients admitted to ICU and/or those who died from COVID-19 infection. The researchers have also reported significant decreases in platelets (PLTs) and lymphocyte counts during infection and the numbers correlated negatively with the severity of COVID-19 [29, 36-41]. While no association between the haematological indices and the risk of dying from COVID-19 infection were reported [29, 38], others showed that anaemia, thrombocytopenia and lymphocytopenia increased the odds of death in their patients [30, 36, 37, 42, 43]. Moreover, numerous reports also disclosed significantly abnormal liver and renal function parameters [29, 36-38, 40, 41]. However, results related to an increased risk of death with the parameters of interest are inconsistent between the studies.

Herein, there were aberrant haematological indices depicted by low RBCs counts, haematocrit value, Hb concentrations, MCV and MCH alongside low PLTs counts and lymphocytopenia in the deceased group. Our findings also showed marked elevations in ALP enzyme, bilirubin, BUN, and creatinine together with decreases in total protein and albumin the deceased group. Nevertheless, none of the haematological parameters increased the odds of death by multivariate analysis, which could possibly be due to small numbers of patients included in our report. Hence, future studies with larger numbers of patients are still needed to accurately calculate the associations between the haematological and biochemical parameters with the severity of COVID-19 infection.

COVID-19 mainly affects the respiratory system, and hyperventilation, hypoxaemia and hypercapnia are common findings and associate directly with the severity of the infection and clinical outcomes [28, 30, 38, 39]. In agreement, the present data demonstrated significant decreases in O_2 pressure and saturation that concurred with declines in pCO_2 and alkalosis in the deceased group. Additionally, the logistical regression analysis revealed a significantly increased risk of death with low O_2 pressure. Our findings suggest the development of type-2 respiratory failure, which is a serious common manifestation of COVID-19 infection, is a major independent risk factor associated with increased infection severity and fatality [44-47].

Limitations

This report has several drawbacks, including the small numbers of cases in addition to missing many variables related to the socioeconomic status, treatment protocols and status of co-morbidities (e.g., cardiovascular and renal diseases, etc.). Furthermore, the patients' data were obtained from a single research site and a multicentre strategy could have reflected the factual death rates and the independent risk factors associated with the severity and fatality of COVID-19 more precisely. Moreover, collecting the clinical, radiological, and biochemical findings during the full duration of hospitalisation could have more accurately elucidated the course of COVID-19 infection in Saudi Arabia.

Future work

We, therefore, suggest to conduct forthcoming multicentre studies to precisely reveal the case fatality rate and complications of COVID-19 infection in KSA, especially after the observed surge in the numbers of cases during the recent weeks [26]. Additionally, data

related to mechanical ventilation, chronic diseases, and socioeconomic status should be detailed in future studies. The roles of the different types of vaccines in preventing viral transmission as well as limiting the severity of COVID-19 is needed for establishing highly effective infection control and public health policies against this highly transmissible viral infection.

5. Conclusions

Males and non-Saudi residents of KSA appeared to be more susceptible for acquiring infection during the first wave of COVID-19 disease. Although liver and renal biochemical parameters, haematological indices, and respiratory functions were significantly altered with COVID-19 infection and more pronounced in the deceased patients, only ICU admission and low O_2 pressure showed higher risks of death from the infection. Nevertheless, additional multicentre studies with larger numbers of patients and more stringent strategies to follow-up the cases are needed to precisely identify the risk factors that could augment the severity and fatality of COVID-19 infection.

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