Characteristics, Treatment, Outcomes, and Cause of Death of Invasively Ventilated Patients with COVID-19 ARDS in Asir Central Hospital, Southern of Saudi Arabia: A Retrospective Single Center Experience

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Introduction: COVID-19's emergence caused devastating consequences worldwide, with high morbidity and mortality rates. Critically ill patients face challenges like acute respiratory failure requiring intensive measures, including mechanical ventilation. Mortality rates in ARDS are influenced by various factors. This paper focuses on describing characteristics, management, and survival factors of mechanically ventilated ICU patients in Saudi Arabia.

Methods: A retrospective, noninterventional approach, we reviewed charts and data of all COVID-19-infected patients who were admitted to the ICU, particularly those requiring ventilation support at Aseer Central Hospital (ACH) in the southern region of Saudi Arabia.

Results: The study enrolled 594 COVID patients, mean age 60.5 ± 17.3 years, with 67% males. Approximately half had O negative blood group. Common chronic health issues: diabetes mellitus (35.5%). Positive culture findings in almost 340 (57.2%), with Klebsiella pneumoniae being the most isolated microorganism (45.5%). Significant correlations found with mortality: age, blood culture, Rh positive group (P<0.05).

Conclusion: This study provides critical insights into the clinical and epidemiological aspects of COVID-19 patients admitted to the ICU in a Saudi Arabian hospital. The research underscores the impact of age, comorbidities, laboratory markers, and treatment interventions on patient outcomes, emphasizing the significance of tailored management strategies in this context.

1. INTRODUCTION

The emergence of coronavirus disease 2019 (COVID-19) in late 2019 resulted in devastating consequences, causing a surge in morbidity and mortality rates. This highly infectious and contagious virus, belonging to the Coronaviridae family, has rapidly spread to every corner of the world, posing significant challenges to economies and healthcare systems worldwide [1,2]. In March 2020, Saudi Arabia confirmed its first COVID-19 case in an adult Saudi national [3]. In response, the Saudi Ministry of Health ramped up preparations and precautions to control the outbreak and meet the medical needs of affected individuals. Over 25 hospitals with a total of 8,800 beds, including 8,000 ICU beds, and 2,200 isolation beds for suspected and quarantined cases were dedicated to providing care and the guidelines for the treatment during the pandemic [4,5]. This substantial effort was crucial in managing the anticipated influx of infected patients.

The disease exhibits flu-like symptoms such as fever, cough, myalgia, and gastrointestinal problems [6]. While the majority of cases are mild, around one-quarter of individuals experience a more severe presentation may progress to acute respiratory distress syndrome (ARDS), and about 5% reach a critical condition [7]. Critically ill COVID-19 patients encounter distinctive challenges, including acute respiratory failure with resistance hypoxemia, coagulopathy, multi system failure, and changes in immunity and inflammatory responses. Due to these complex and multifaceted complications, managing these patients demands careful and attentive care [8].

The critical care management of these patients in the ICU involves the implementation of generic measures and evidence-based medicine guidelines, including invasive mechanical ventilation (MV) [9]. The mortality rates in ARDS, which arise from mixed etiologies, are influenced by several factors, such as patients' co-morbidities, age, severity of hypoxemia, and the presence of co-existing organ failures [10].

While various studies have explored the clinical characteristics of ICU patients in Saudi Arabia, there remains a limited amount of research specifically centered on those who needed mechanical ventilation. This paper aims to fill this gap by providing insights into the characteristics and management of critically ill COVID-19 patients admitted to ICUs, focusing on those requiring mechanical ventilation. Additionally, we investigate factors associated with patient survival in this subgroup.

2. METHODS

Our study delved into COVID-19 ICU admissions at Aseer Central Hospital (ACH) in the southern region of Saudi Arabia. Using a retrospective, noninterventional approach, we reviewed charts and data of all COVID-19-infected patients who were admitted to the ICU, particularly those requiring ventilation support. our study comprised a sample size of 594 patients meeting the inclusion criteria of hospitalized patients aged 18 years and above, diagnosed by positive real-time polymerase chain reaction tests for SARS-CoV-2. The data analysis spanned from August 2020 to April 2021.

The study encompassed various variables, and we meticulously collected and organized data pertaining to the patients' demographics. This included information on age, gender, nationality, and the presence of comorbidities. Additionally, we focused on the ICU profile, which encompassed ICU-based interventions. Our primary outcome of interest was the study of patient mortality and blood group type association. This study obtained approval from the Institutional Review Board in Aseer Central Hospital and research committee.

2.1 Data Analysis

After extracting the data, it underwent revision, coding, and was then entered into the statistical software IBM SPSS version 26 (SPSS, Inc. Chicago, IL). Two-tailed tests were used for all statistical analyses, considering a p-value less than 0.05 as statistically significant. Descriptive statistics, including mean with standard deviation, were utilized for scale and continuous variables such as laboratory findings, while frequency and percentages were used for categorical variables like personal data and blood group. To assess factors associated with mortality among COVID-19 patients, cross-tabulation was employed. Additionally, the relationship with mortality was analyzed using Chi-square and exact tests, the latter being suitable for small sample sizes. Logistic regression analysis was applied to determine the magnitude of the relationship between blood group, Rh factor, and patients' mortality rate. Mortality rates, co-morbidities, medication usage, culture findings, and other relevant variables were presented graphically for a comprehensive understanding.

3. RESULTS

This study included 594 COVID patients admitted to Aseer Central Hospital (ACH) ICU. The patients' ages ranged from 18 to 103 years, with a mean age of 60.5 ± 17.3 years. Among them, 398 (67%) were males, and only 5 (0.8%) were smokers (Table 1).

Fig. 1 displays the prevalence of chronic diseases among COVID patients admitted to the ICU at Aseer Central Hospital (ACH), Saudi Arabia. The most commonly reported chronic health issues in this study included diabetes mellitus (35.5%), dyslipidemia (13%), gastrointestinal diseases (5.1%), chronic kidney disease (5.1%), bronchial asthma (3.9%), and hypothyroidism (3.5%).

Fig. 2 illustrates the medications administered to COVID patients admitted to the ICU. Upon admission, 95.3% received antibiotics, 87.4% were prescribed anticoagulants, 78.3% received steroids, 75.3% were given antiviral drugs, and 55.4% received analgesics. Monoclonal antibodies (MABS) were administered to 20.4% of patients, and 14.5% received antiplatelet medication. The average laboratory findings of COVID patients admitted to Aseer Central Hospital (ACH) ICU are displayed. The blood glucose level (BGL) was recorded as 276.7 ± 12.1 mg/dl, creatinine as 2.6 ± 1.9 g/dl, erythrocyte sedimentation rate (ESR) as 62.8 ± 35.6, and C-reactive protein (CRP) as 60.4 ± 62.9 (Table 2). Regarding chest X-ray findings, tracheostomy tubes were observed in 235 (98.7%) patients, while only 6 (2.5%) displayed signs of consolidation.

Almost 340 (57.2%) had positive culture findings. The most commonly isolated microorganisms included Klebsiella pneumoniae (45.5%), Acinetobacter (20.2%), Staphylococcus epidermidis (13.8%), Pseudomonas aeruginosa (6.2%), MSSA (5.6%), Staphylococcus haemolyticus (4.7%), and Enterococcus faecium (4.7%) (Fig. 3). Among the patients, 320 (54.6%) died, while 266 (45.4%) survived (Fig. 4),

In this study, a significant correlation was found between age and mortality, with 75% of patients aged 70 years or more succumbing to the disease compared to 22.5% of those under 40 years (P=.001). Patients with positive culture results also had a higher mortality rate of 67.4% compared to 37.7% for those with negative culture findings (P=.001), Other factors examined did not show significant relations with COVID patients' mortality (Table 3).

Table 1. Personal characteristics of covid patients admitted to ICU, ACH, Saudi Arabia

Personal data	No	%
Age in years		
< 40	72	12.1%
40-59	193	32.5%
60-69	127	21.4%
70+	202	34.0%
Mean ± SD	60.5 ± 17.3	
Gender		
Male	398	67.0%
Female	196	33.0%
Smoking		
No	589	99.2%
Yes	5	.8%

Table 2. Laboratory findings among covid patients admitted to ICU, ACH, Saudi Arabia

Laboratory findings	Mean	SD
Creatinine	2.6	1.9
Hb	13.3	2.9
WBCs	19.9	12.0
Platelets	131.8	132.1
LDL	78.3	59.4
HDL	35.1	17.4
ESR	62.8	35.6
CRP	60.4	62.9
BGL	276.7	129.1
Total bilirubin	1.8	2.1

Table 3. Factors associated with mortality among covid patients admitted to ICU, ACH, Saudi Arabia

Factors	Death				p-value
	No		Yes		
	No	%	No	%	
Age in years					.001*
< 40	55	77.5%	16	22.5%	
40-59	110	58.2%	79	41.8%	
60-69	51	40.5%	75	59.5%	
70+	50	25.0%	150	75.0%	
Gender					.221
Male	171	43.6%	221	56.4%	
Female	95	49.0%	99	51.0%	
Smoking					.510$
No	263	45.3%	318	54.7%	
Yes	3	60.0%	2	40.0%	
DM					.578
No	167	44.5%	208	55.5%	
Yes	99	46.9%	112	53.1%	
Culture					.001*
No	157	62.3%	95	37.7%	
Yes	109	32.6%	225	67.4%	

P: Pearson X^2 test
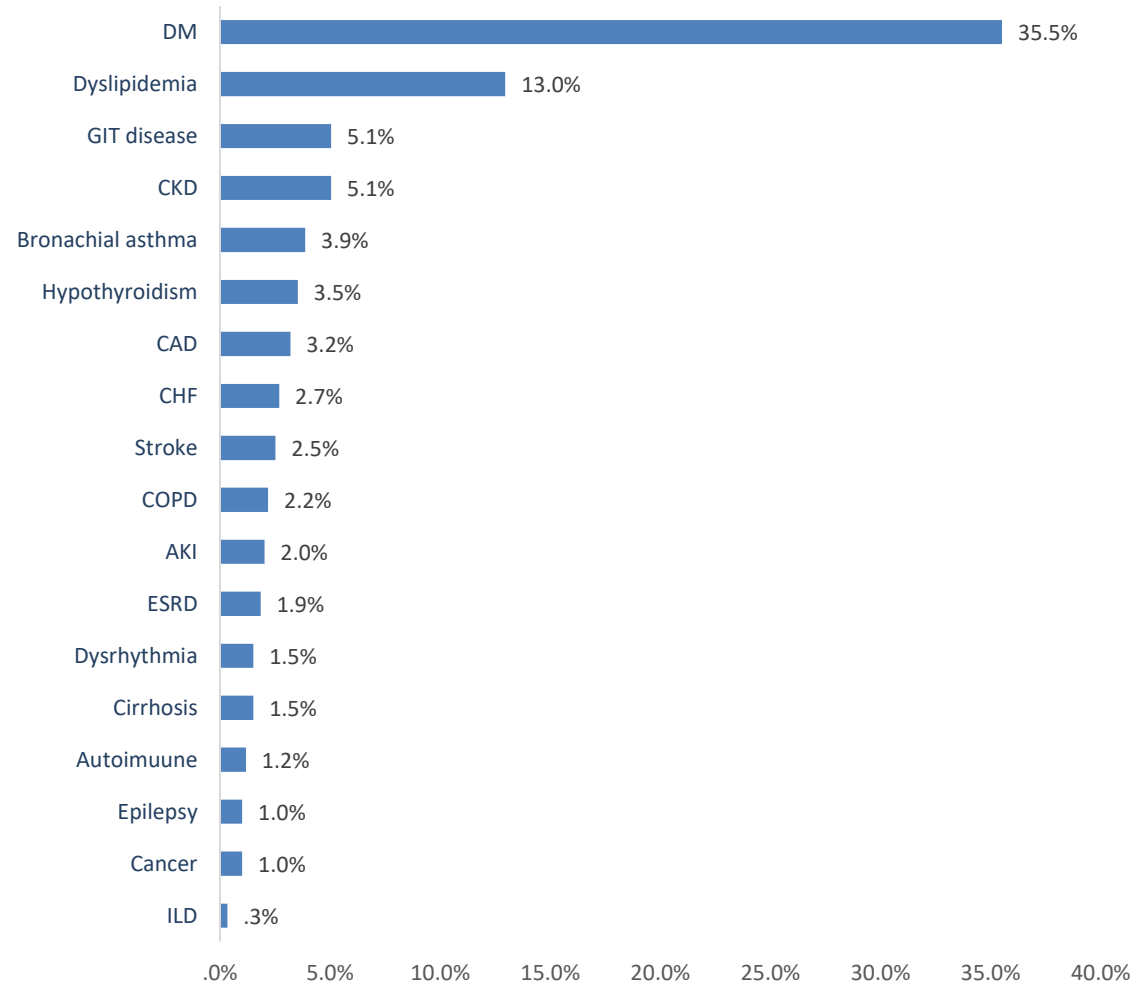*$: Exact probability test*
* P < 0.05 (significant)

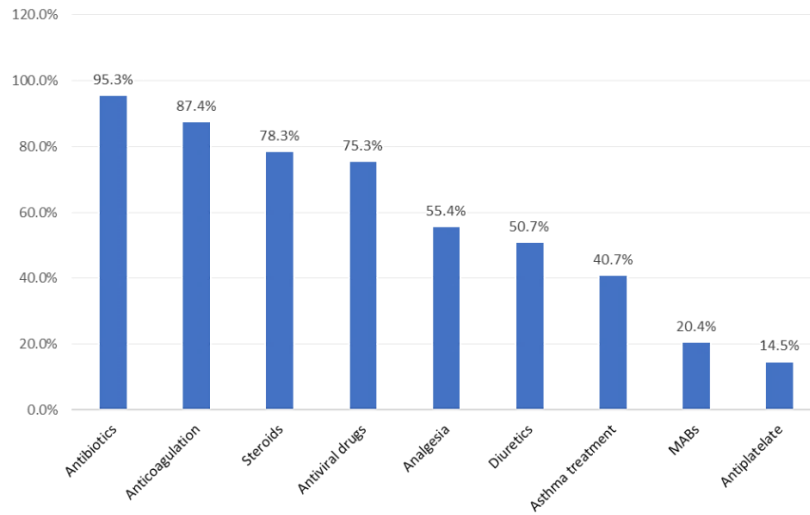**Fig. 1. Chronic diseases among covid patients admitted to ICU, ACH, Saudi Arabia**

Fig. 2. Medications taken by covid patients admitted to ICU, ACH, Saudi Arabia
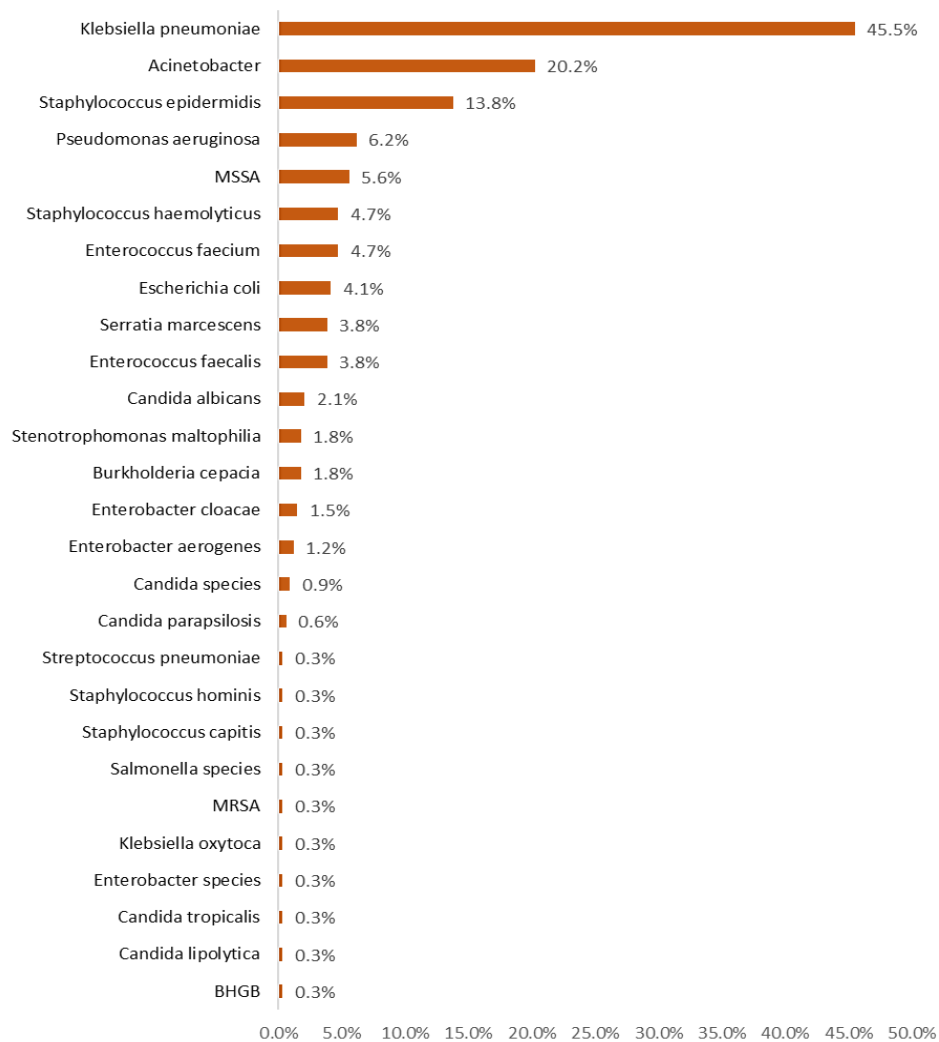

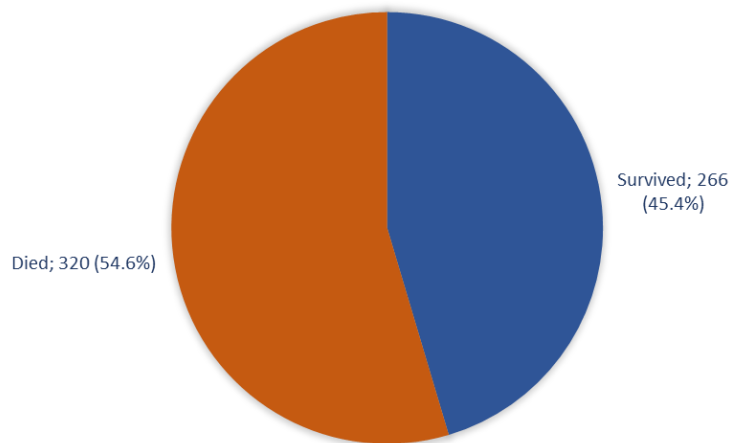**Fig. 3. Culture findings among covid patients admitted to ICU, ACH, Saudi Arabia**

Fig. 4. Death rate among covid patients admitted to ICU, ACH, Saudi Arabia

4. DISCUSSION

ICU admission is necessary for up to 25% of hospitalized COVID-19 patients. Identifying high-risk individuals is crucial to reduce mortality and enhance clinical outcomes in severe cases [11,12,13]. This paper aim to provide insights into the characteristics and management of critically ill COVID-19 patients admitted to ICU, particularly those needing mechanical ventilation. Additionally, the study investigates factors associated with patient survival within this specific subgroup.

In line with other published studies, two third of our study papulation were male, as observed in other national and international reports [14,15,16]. Over 50% of our ICU-admitted COVID-19 patients are aged 60 years or older, consistent with findings from both local and international studies. Older patients tend to experience more severe disease and complications, which can be attributed to factors such as the presence of multiple comorbidities, lower immunity, and an increased risk for complications. Understanding these risks is essential for providing targeted care and improving outcomes for this vulnerable population [14,17,18,19].

Undoubtedly, the presence of comorbidities is recognized to complicate the severity and mortality of COVID infections [11,20]. The escalating prevalence of diabetes mellitus (DM) presents a major public health challenge, leading to considerable long-term morbidity and mortality. A Gulf region study underscored Saudi Arabia's record for the highest diabetes-related deaths in general [21]. This study revealed that more than one-third of patients had a diagnosis of DM, aligning with evidence indicating that nearly half of Saudi individuals aged over 55 have DM2. This pattern is consistent with our patient age group [22]. Notably, our DM prevalence was higher than a study in Alahsa [14], which found around 20% DM prevalence in COVID patients, although some were not in the ICU. Additionally, another cohort study on COVID patients indicated that almost half had DM [17].

Certain studies have investigated the correlation between laboratory parameters and COVID-19. These parameters encompass procalcitonin (PCT), lactic acid, percentage of lymphocytes, D-dimer levels, C-reactive protein (CRP), erythrocyte sedimentation rate (ESR) and serum lactate dehydrogenase (LDH) [23,24]. Laboratory assessments of our patients revealed elevated renal profile, hepatic enzymes, and inflammatory markers, particularly ESR and CRP. Such markers have demonstrated a strong association with COVID-19 mortality in previous studies. These results underscore the substantial role of inflammation in the pathophysiology of COVID-19 in critically ill patients. Additionally, our findings propose that CRP might play an independent role in ICU admission [25,26,19,14]. Administering dexamethasone to moderate to severely hypoxic COVID-19 patients has become standard practice due to improved outcomes. Furthermore, a multicenter study highlighted

reduced mortality by combining antibiotics with hydroxychloroquine in COVID-19 cases [27,28,29]. Remarkably, over two-thirds of our studied patients received antibiotics and steroids, adhering to health protocols and local guidelines [5].

This study revealed a high rate of mortality in severely COVID patients who admitted to ICU and on mechanical ventilation with a noteworthy connection between age and mortality. Additionally, patients with positive culture outcomes experienced an elevated mortality rate. This finding aligns with several local studies in Saudi Arabia and a comprehensive analysis involving 178,568 COVID-19 deaths across 16 countries. This broader study indicated an approximately 8-fold higher mortality rate among those aged 55 to 64, and an astonishing more than 62-fold higher incidence rate among those aged 65 or older, in comparison to individuals aged 54 or younger [16,18,19,24,25,30]. This can be ascribed to immunosenescence, a phenomenon where the performance of innate immune cells in older individuals becomes compromised. This leads to diminished viral clearance efficacy and the commencement of an imbalanced immune response [31].

5. CONCLUSION

This study provides critical insights into the clinical and epidemiological aspects of COVID-19 patients admitted to the ICU in a Saudi Arabian hospital. The research underscores the impact of age, comorbidities, laboratory markers, and treatment interventions on patient outcomes, emphasizing the significance of tailored management strategies in this context.

DISCLAIMER

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The preprint document is available in this link: https://www.researchgate.net/publication/376524 737_Characteristics_Treatment_Outcomes_and_ Cause_of_Death_of_Invasively_Ventilated_Patie nts_with_COVID- 19_ARDS_in_Asir_Central_Hospital_A_Retrospe ctive_Single_Center_Experience

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Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

CONSENT

As per international standards or university standards, patient(s) written consent has been collected and preserved by the author(s).

ETHICAL APPROVAL

As per international standards or university standards written ethical approval has been collected and preserved by the author(s).

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Benvenuto D, Giovanetti M, Ciccozzi A, Spoto S, Angeletti S, Ciccozzi M. The 2019-new coronavirus epidemic: Evidence for virus evolution. J Med Virol. 2020; 92(4):455–459. DOI:10.1002/jmv.25688
2. Lai C, Shih T, Ko W, Tang H, Hsueh P. Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) and coronavirus disease-2019 (COVID-19): The epidemic and the challenges. Int J Antimicrob Agents. 2020;55(3):105924. DOI:10.1016/j.ijantimicag.2020.105924
3. Saudi Ministry of Health. MOH reports first case of Coronavirus infection; 2021. [cited 2 January 2021].
   Available:https:// www. moh. gov. sa/ en/ Minis try/ Media Center/ News/ Pages/ News-2020-03-02-002. aspx.
4. Barry M, Ghonem L, Alsharidi A, Alanazi A, Alotaibi NH, Al-Shahrani FS, et al. Coronavirus disease-2019 pandemic in the Kingdom of Saudi Arabia: Mitigation measures and hospital preparedness. J Nat Sci Med. 2020;3(3):155.
   Available:https://doi.org/10.4103/JNSM.JN SM_29_20
5. Saudi Ministry of Health. ICU Triage, Admission, and Discharge Criteria during the COVID 19 pandemic V2; 2020. [cited 30 April 2021].

Available:https:// www. moh. gov. sa/ Minis try/ Media Center/ Publi catio ns/ Docum ents/ ICUCrite ria-during. pdf.

6. Chen N, Zhou M, Dong X, Qu J, Gong F, Han Y, et al. Epidemiological and clinical characteristics of 99 cases of 2019 novel coronavirus pneumonia in Wuhan, China: A descriptive study. Lancet. 2020; 395(10223):507-13.
Available:https://doi.org/10.1016/S0140-6736(20)30211-7

7. Zhou F, Yu T, Du R, Fan G, Liu Y, Liu Z, et al. Clinical course and risk factors for mortality of adult inpatients with COVID-19 in Wuhan, China: A retrospective cohort study. Lancet. 2020;395(10229):1054-62.
Available:https://doi.org/10.1016/S0140-6736(20)30566-3.

8. Lillicrap D. Disseminated intravascular coagulation in patients with 2019-nCoV pneumonia. J Thromb Haemost. 2020; 18(4):786-7.
Available:https://doi.org/10.1111/jth.14781.

9. Claesson J, Freundlich M, Gunnarsson I, et al. Scandinavian clinical practice guideline on mechanical ventilation in adults with the acute respiratory distress syndrome. Acta Anaesthesiol Scand. 2015; 59:286-297.

10. Murthy S, Gomersall CD, Fowler RA. Care for critically Ill patients with COVID-19. JAMA. 2020;323:1499-1500.
Available:https://doi.org/10.1001/jama.2020.3633.

11. Wang D, Hu B, Hu C, Zhu F, Liu X, Zhang J, Wang B, Xiang H, Cheng Z, Xiong Y. Clinical characteristics of 138 hospitalized patients with 2019 novel coronavirus infected pneumonia in Wuhan, China. JAMA. 2020;323(11):1061–9.

12. Vahidy FS, Drews AL, Masud FN, Schwartz RL, Boom ML, Phillips RA. Characteristics and outcomes of COVID-19 patients during initial peak and resurgence in the Houston metropolitan area. JAMA. 2020;324(10):998–1000.

13. Guan W-J, Ni Z-Y, Hu Y, Liang W-H, Ou C-Q, He J-X, Liu L, Shan H, Lei C-L, Hui DS. Clinical characteristics of coronavirus disease 2019 in China. N Engl J Med. 2020;382(18):1708–20.

14. Saad Alhumaid, Abbas Al Mutair, Zainab Al Alawi, Khulud Al Salman, Nourah Al Dossary, Ahmed Omar. Clinical features and prognostic factors of intensive and non-intensive 1014 COVID-19 patients: An experience cohort from Alahsa, Saudi Arabia, European Journal of Medical Research. 2021;26:47.
Available:https://doi.org/10.1186/s40001-021-00517-7.

15. Shruti Gupta, MD, MPH; Salim S. Hayek, MD, WeiWang, PhD Lili Chan, MD, MSCR, Kusum S. Mathews, MD, MPH, MSCR, Michal L. Melamed, MD, MHS, Samantha K. Brenner, MD, MPH. Factors associated with death in critically Ill patients with coronavirus disease 2019 in the US, JAMA Intern Med; 2020. Published online July 15, 2020.
DOI:10.1001/jamainternmed.2020.3596

16. Al-Omari A, Alhuqbani WN, Zaidi ARZ, Al-Subaie MF, AlHindi AM, Abogosh AK, Alrasheed AK, Alsharafi AA, Alhuqbani MN, Salih S. Clinical characteristics of non-intensive care unit COVID-19 patients in Saudi Arabia: A descriptive cross-sectional study. J Infect Public Health. 2020;13(11): 1639–44.

17. Aljuaid M, Alotair H, Alnajjar F, Alonazi W, Sharaf H, Sheshah E, et al. Risk factors associated with in-hospital mortality patients with COVID-19 in Saudi Arabia. Plos One. 2022;17(6):e0270062.
Available:https://doi.org/10.1371/journal.pone.0270062

18. Al-Otaiby M, Almutairi KM, Vinluan JM, Al Seraihi A, Alonazi WB, Qahtani MH, Aljeri T, Alhumud MA, Alobaidi N, Alhurishi SA. Demographic characteristics, comorbidities, and length of stay of COVID-19 patients admitted into intensive care units in Saudi Arabia: A nationwide retrospective study. Front. Med. 2022; 9:893954.
DOI: 10.3389/fmed.2022.893954.

19. Saleh Alghamdi. Clinical characteristics and treatment outcomes of severe (ICU) COVID-19 patients in Saudi Arabia: A single centre study, Saudi Pharmaceutical Journal. 2021;29:1096–1101.

20. Alenazi AM, Alqahtani BA. National and regional prevalence rates of hypertension in Saudi Arabia: A descriptive analysis using the national survey data. Front Public Health. 2023, Apr 4;11:1092905.
DOI: 10.3389/fpubh.2023.1092905.
PMID: 37081959; PMCID: PMC10110943.

21. Aljulifi MZ. Prevalence and reasons of increased type 2 diabetes in Gulf cooperation council countries. Saudi Med J. 2021;42:481–90.

22. Jarrar M, Abusalah MAH, Albaker W, Al-Bsheish M, Alsyouf A, Al-Mugheed K, Issa

MR, Alumran A. Prevalence of type 2 diabetes mellitus in the general population of Saudi Arabia, 2000-2020: A systematic review and meta-analysis of observational studies. Saudi J Med Med Sci. 2023, Jan-Mar;11(1):1-10.
DOI: 10.4103/sjmms.sjmms_394_22.
Epub 2023 Jan 14. PMID: 36909010; PMCID: PMC9997860.

23. Tan L, Kang X, Ji X, et al. Validation of predictors of disease severity and outcomes in COVID-19 patients: a descriptive and retrospective study. Med. 2020;1(1):128–138.e3.
DOI: 10.1016/j.medj.2020.05.002.

24. Alharthy A, Aletreby W, Faqihi F, et al. Clinical characteristics and predictors of 28-day mortality in 352 critically ill patients with COVID-19: A retrospective study. J Epidemiol Glob Health. 2021; 11(11):98.
DOI: 10.2991/jegh.k.200928.001.

25. Ansari KA, Alwazzeh MJ, Alkuwaiti FA, Farooqi FA, Al Khathlan N, Almutawah H, Alahmed M, Alfaraj H, Aljarrash A, Almadhary J, Alwarthan S, Alsahlawi AM, Almashouf AB, Alqasim M, Alkuwaiti E. Early determinants of mortality in hospitalized COVID-19 patients in the Eastern province of Saudi Arabia. Int J Gen Med. 2022, Feb 16;15:1689-1701.
DOI: 10.2147/IJGM.S349598.
PMID: 35210838; PMCID: PMC8858956.

26. Sadeghi A, Eslami P, Dooghaie Moghadam A, Pirsalehi A, Shojaee S, Vahidi M, Soheili A, Ghanimat F, Keshmiri Y, Abdi S, Zali MR. COVID-19 and ICU admission associated predictive factors in Iranian patients. Caspian J Intern Med. 2020, Fall;11(Suppl 1):512-519.
DOI: 10.22088/cjim.11.0.512.
PMID: 33425268; PMCID: PMC7780877.

27. Rosenberg ES, Dufort EM, Udo T, Wilberschied LA, Kumar J, Tesoriero J, et al., Association of treatment with hydroxychloroquine or azithromycin with in-hospital mortality in patients with COVID-19 in New York State. Jama. 2020, Jun 23; 323(24):2493–502.
Available:https://doi.org/10.1001/jama.2020.8630, PMID: 32392282.

28. Arshad S, Kilgore P, Chaudhry ZS, Jacobsen G, Wang DD, Huitsing K, et al. Treatment with hydroxychloroquine, azithromycin, and combination in patients hospitalized with COVID-19. International Journal of Infectious Diseases. 2020, Aug 1; 97:396–403.
Available:https://doi.org/10.1016/j.ijid.2020.06.099 PMID:32623082.

29. Wootton D. Dexamethasone in hospitalized patients with COVID-19. New England Journal of Medicine. 2021, Feb 25; 384(8):693–704. PMID: 32678530.
Available:https://doi.org/10.1056/NEJMoa2021436

30. Yanez ND, Weiss NS, Romand J-A, Treggiari MM. COVID-19 mortality risk for older men and women. BMC Public Health. 2020;20(1):1–7.

31. Kang SJ, Jung SI. Age-related morbidity and mortality among patients with COVID-19. Infection & Chemotherapy. 2020, Jun; 52(2):154.
https://doi.org/10.3947/ic.2020.52.2.154
PMID: 32537961

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