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ORIGINAL RESEARCH

# Characteristics of Hospitalized COVID-19 Patients in the Four Southern Regions Under the Proposed Southern Business Unit of Saudi Arabia

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**Background:** This is the first descriptive and comparative study conducted of COVID-19 inpatients from multi-centers in the four administrative southern regions and proposed Southern Business Unit (Jazan, Najran, Bisha, and Aseer) of the Kingdom of Saudi Arabia (KSA).

**Methods:** Participants were 809 randomly selected patients admitted to the eight sampled hospitals with confirmed COVID-19 between March 2020 and February 2021. We assessed and compared socio-demographics, clinical characteristics, and clinical outcomes of the four regions.

**Results:** Socio-demographic and clinical characteristics of the participants are a mean age of 60 ± 17.7 years, 70% Saudi male, the prevalence of diabetes (DM2) 58%, hypertension (HTN) 48%, obesity 43%, cardiac diseases 15%, and immunity or cancer diseases almost 1%. The prevalence of complications during admission were bacterial pneumonia 65%, acquired respiratory distress syndrome (ARDS) 32%, sepsis 20%, multi-organ failure 18%, acute kidney diseases 15%, and arrhythmia 4%. Clinical outcomes were: admitted to intensive care unit (ICU) 52%, mortality rate 25%, referred to other facilities 9%, and mean length of stay (LOS) was 11± 9.5 days. We observed statistically significant variation in many variables among the four regions. Najran and Aseer had a higher prevalence of risk factors for severity including age and comorbidities accompanied by higher rates of complications, ICU admissions, LOS, and mortality. Bisha and Jazan had lower prevalence of risk factors and LOS with lower rates of complications, ICU admissions, and mortality.

**Conclusion:** This study reveals that the geographic region in which the patient was cared for was related to the severity and outcome of COVID-19 infection. Policy makers should search for solutions to regional differences in underlying health conditions such as DM2, HTN, and obesity to plan for improvements in preventive care as well as resource distribution to ensure quality for all Saudi citizens. This study will serve as guidance to begin to form strategies for these improvements as envisioned in the future New Model of Care.

**Keywords:** COVID-19, inpatient characteristics, demographic and clinical characteristics, clinical course, outcomes, and complications, Southern Business Unit, Saudi Arabia

## Introduction

Coronavirus disease 2019 (COVID-19) caused by severe acute respiratory syndrome coronavirus 2 (SARS-Cov-2) is a persistent infectious disease that has spread across 224 countries with more than 439 million confirmed cases to date



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and climbing and more than 5 million deaths globally as of March 3, 2022[1–3]. The first case of COVID-19 was reported in Wuhan, China on December 31, 2019 and by March 11, 2020 The World Health Organization (WHO) escalated COVID-19 from a global health emergency to a pandemic.[4] The first case of COVID-19 appeared in Saudi Arabia on March 2, 2020,[5] and as of March 3, 2022, there have been 746,066 cases of the disease and 9002 deaths.[6,7]

Complications linked to COVID-19 include bacterial pneumonia, sepsis, acute respiratory distress syndrome (ARDS), acute kidney injury, multi-organ failure, thromboembolism, and others.[8,9] As previously reported by several studies, health care resources throughout the world faced multiple challenges in meeting the surge in COVID-19 patients, including demand for intensive care units (ICUs) and other critical care services, the wide range of symptoms, complications, and outcomes requiring continual upgrading of treatment modalities, severe and persistent shortages of equipment and staff, and efficient distribution of the burden, among others.[9–11] Along with the toll on health care systems around the world, the COVID-19 pandemic has significantly disrupted socio-economic systems globally including food production and distribution, the supply chain, and the survival of many enterprises.[12,13]

With such a devastating global disruption of all aspects of life, we might expect to see regional variations in response that have an impact on outcomes. Prior to the current pandemic, the healthcare system in the KSA was already facing many challenges in order to provide services due to decreasing revenue, population aging, population growth, and increasing urban lifestyle.[14] Initiatives are in place under Vision 2030 using its New Model of Care (MOC) to address the challenges to the healthcare system and to improve the standard of care in the face of the rising population, increases in life expectancy, and increasing rates of preventable non-communicable diseases such as diabetes mellitus, obesity, and cardiovascular conditions.[15] The pandemic has disrupted the healthcare system just as the transition of the healthcare system under Vision 2030 has begun, providing an opportunity to measure many quality factors using this rare occurrence.[8,16]

The current healthcare system is administered by the Ministry of Health (MOH) through 13 administrative regions. Under Vision 2030 the 13 regions are proposed to be consolidated into five business units (BUs) designated as Northern, Southern, Central, Eastern, and Western. The healthcare system will transform from a combination of public and private to a hybrid system of privatization in which a private insurance company will administer healthcare in each BU under a government-owned holding company and financial administration will remain with the government through a yet to be formed national insurance center under the auspices of the MOH.[17] The Southern BU is composed of four regions in the southern KSA, Jazan, Najran, Bisha, and Aseer.[17]

The literature contains many studies of the close association of socio-demographic factors and variations in COVID-19 outcomes. Age and gender are significant factors in severity of COVID-19 as reported by several studies revealing that both advanced age and male gender predispose patients to worse outcomes.[1,9,18] The association of ethnicity with COVID-19 outcomes has been studied and a large review found that studies showed mixed results, for example in U.S studies, being Hispanic or Black was related to increased hospitalization but not to severity or mortality in some studies but was in other studies, while a study in England observed that being black or South Asian represented a greater risk of mortality.[9,19,20] One of the studies from England revealed that being black, Asian, or of minority ethnicity was a risk factor for severity of disease and death at a younger age than the white patients including among healthcare professionals.[19] Many international studies have reported on the relationship of comorbidities to COVID-19 outcomes. Most scholars agree that HTN, DM2, cardiovascular diseases, and chronic liver and kidney diseases are related to severity and mortality in COVID-19 inpatients.[1,9,21–24] COVID-19 disease causes many serious complications that factor into the severity of the outcome. Significant complications reported include multi-organ failure, ARDS, bacterial pneumonia, acute kidney injury, acute liver injury, coagulation disorders, thromboembolism, and others.[9,25] Regional differences in hospitalization and clinical courses of COVID-19 have been discovered by both international and domestic studies. A 2021 systematic review of 80 studies to analyze COVID-19 risk factors based on patient continent of residence revealed many differences between continents, while a recent study in the KSA also revealed regional differences among the 13 regions.[8,26] Along with the global health crisis posed by COVID-19, there has been massive social and economic upheaval with schools closing, travel severely restricted, and job loss.[12,13]

The primary objective of this study was to ascertain whether there are variations among the four regions of southern KSA; Bisha, Jazan, Najran, and Aseer, in their socio-demographic characteristics and healthcare outcomes in association with COVID-19 inpatients. The results of this study should be useful for policymakers to improve the healthcare system overall and to address variations among the regions of the southern administrative region.

# Materials and Methods

## Design, Participants and Setting

This is a comparative descriptive retrospective study using secondary data compiled by the MOH of the KSA from March, 2020 through February, 2021. We enrolled 809 participants with confirmed moderate to severe COVID-19 from eight hospitals scattered throughout Bisha, Jazan, Najran, and Aseer, KSA. Our randomly selected sample was composed of inpatients >17 years of age who were treated for moderate to severe COVID-19 in hospitals in the four regions during our sampling time period. Free medical care was provided for all COVID-19 patients including Non-Saudis who are residents of the KSA.

## Data Source

At the beginning of the pandemic, the MOH assigned specific hospitals to care for COVID-19 patients. Hospitals submitted data for all inpatients with COVID-19 to the MOH. We extracted the data for 809 participants from the MOH database for eight hospitals located throughout the four regions of southern KSA: Bisha, Jazan, Najran, and Aseer.

## Statistical Analysis

Four statistical methods were utilized as appropriate to analyze and test the data on 809 participants. Comparative and descriptive statistics were first applied then Chi-square test, one-way ANOVA, and independent sample *t*-test with STATA version 14 software used for all statistical analyses. All statistical tests were two-sided. Statistical significance was assigned a p-value $\leq 0.05$. Variables were classified as either categorical, binary, or continuous. Region was the variable of interest, a categorical variable, as follows: 0 = Bisha, 1 = Jazan, 2 = Najran, and 3 = Aseer. Other variables were inpatient characteristics including the socio-demographics of age, gender, and nationality; the comorbidities of DM2, HTN, obesity, cardiac disease, immunocompromised, and history of cancer; clinical course of the disease such as stage at admission, complications, and length of stay; and the clinical outcomes of ICU admission, discharge status, transfer to another facility, and death in hospital. Binary variables were reported as 0 = No and 1 = Yes. Continuous variables were reported as means and standard deviation. Patients were triaged at initial admission by severity as Stage A defined as having mild to moderate symptoms and was either suspected of having COVID-19 or with a confirmed PCR test, Stage B having severe symptoms and with a confirmed PCR test, or Stage C having critical symptoms with a confirmed PCR test.[27]

## Ethical Considerations

The ethics of this study was approved by the MOH Central Institutional Review Board. Standard precautions were taken to protect the confidentiality and privacy of this secondary data.

# Results

## Demographic and Clinical Characteristics of COVID-19 Inpatients by Regions in Southern KSA

Table 1 presents the demographics and comorbidities of COVID-19 inpatients from hospitals throughout the four regions of southern KSA. The mean age of the total sample was 60 ± 17.6 years, regions listed oldest to youngest participants were Najran (63.5 ± 18.6), Aseer (60.1 ± 17.2), Bisha (59.7 ± 17.8), and Jazan (56.5 ±17.3) years. Throughout all regions males represented two-thirds to three-fourths of participants. Saudi participants represented 71% of the total sample, however, statistically, significant differences are revealed among the regions with the highest to the lowest percentages being Bisha (78%), Aseer (70%), Najran, and Jazan equal at 64% and 63% respectively (p=0.006). More than half (58%) of the total sample had pre-existing diabetes with statistically significant variation between regions. Diabetes rates were significantly higher in Najran (64%) and Aseer (62%) and lower in Jazan (44%) and Bisha (54%) (p=0.003). Of the total sample, 47% had hypertension while Najran and Aseer had relatively higher rates, 53% and 51% respectively, and Jazan and Bisha had lower rates at 43% and 42% respectively, the differences were not statistically significant. Of the total sample, 43% were obese while obesity was significantly higher in Najran (49%) and in Aseer (53%) and lower in Bisha (33%) and Jazan (31%)

**Table 1** Demographic and Clinical Characteristics of COVID-19 Inpatients by Regions in Southern KSA

| Characteristics | Frequency (n and %) | | | | | Chi-Square or #One Way ANOVA |
|---|---|---|---|---|---|---|
| | Total N (%) | Jazan n (%) | Najran n (%) | Bisha n (%) | Aseer n (%) | |
| **Population** | **809 (100%)** | **98 (12%)** | **120 (15%)** | **267 (33%)** | **324 (40%)** | ***p. value*** |
| **Demographics** | | | | | | |
| Age (>17 years) mean (SD) | 60.0 (±17.6) | 56.5 (±17.3) | 63.5 (±18.6) | 59.7 (±17.8) | 60.1 (±17.2) | 0.020#* |
| Gender | | | | | | |
| Male | 576 (71.0%) | 72 (73.0%) | 79 (66.0%) | 182 (68.0%) | 243 (75.0%) | 0.144 |
| Female | 233 (29.0%) | 26 (27.0%) | 41 (34.0%) | 85 (32.0%) | 81 (25.0%) | |
| Nationality | | | | | | |
| Non-Saudi | 234 (29.0%) | 36 (37.0%) | 43 (36%) | 58 (22%) | 97 (30%) | 0.006** |
| Saudi | 575 (71.0%) | 62 (63.0%) | 77 (64%) | 209 (78%) | 227 (70%) | |
| **History of chronic diseases** | | | | | | |
| Diabetes | | | | | | |
| No | 342 (42.0%) | 55 (56.0%) | 43 (36.0%) | 122 (46.0%) | 122 (38.0%) | 0.003** |
| Yes | 467 (58.0%) | 43 (44.0%) | 77 (64.0%) | 145 (54.0%) | 202 (62.0%) | |
| Hypertension | | | | | | |
| No | 426 (53.0%) | 56 (57.0%) | 56 (47.0%) | 155 (58.0%) | 159 (49.0%) | 0.063 |
| Yes | 383 (47.0%) | 43 (43.0%) | 64 (53.0%) | 112 (42.0%) | 165 (51.0%) | |
| Obesity | | | | | | |
| No | 462 (57.0%) | 68 (69.0%) | 61 (51.0%) | 180 (67.0%) | 153 (47.0%) | <0.001*** |
| Yes | 347 (43.0%) | 30 (31.0%) | 59 (49.0%) | 87 (33.0%) | 171 (53.0%) | |
| Cardiac diseases | | | | | | |
| No | 688 (85.0%) | 85 (87.0%) | 83 (69.0%) | 236 (88.0%) | 284 (88.0%) | <0.001*** |
| Yes | 121 (15.0%) | 13 (13.0%) | 37 (31.0%) | 31 (12.0%) | 40 (12.0%) | |
| Immunocompromised | | | | | | |
| No | 797 (98.5%) | 91 (92.0%) | 117 (97.5%) | 267 (100.0%) | 322 (99.0%) | <0.001*** |
| Yes | 12 (1.50%) | 7 (8.0%) | 3 (2.5%) | 0 (0.0%) | 2 (1.0%) | |
| History of cancer | | | | | | |
| No | 802 (99.0%) | 98 (100.0%) | 120 (100.0%) | 263 (98.5%) | 321 (99.0%) | 0.367 |
| Yes | 7 (1.0%) | 0. (0.0%) | 0 (0.0%) | 4 (1.5%) | 3 (1.0%) | |

**Notes**: Results were offered as frequency (number (n) and percent (%)). Correlation between variables was evaluated using the chi-square test. *Significant difference at p ≤ 0.05, **significant difference at p ≤ 0.01, and ***significant difference at p ≤ 0.001; #*p.* value based on One Way ANOVA test for continuous variables.

(p≤0.001). Cardiac diseases occurred in 15% of the total sample but were doubled in Najran (p≤0.001) and occurred at lower frequency than the total sample in the other three regions. Pre-existing immunocompromised conditions showed statistically significant differences between regions with the total sample having a rate of 1.5%, Jazan and Najran participants had rates of 7% and 2.5% respectively, Aseer with a rate of only 1%, and none were found in Bisha (p≤0.001). A history of cancer was rare and showed no statistically significant difference among the regions.

## Clinical Course, Outcomes, and Complications of COVID-19 Inpatients by Region in Southern KSA

Table 2 presents the regional outcomes and complications of COVID-19 inpatients. To assess the initial severity of a case, patients were categorized by the stage of the disease with severity increasing alphabetically, see statistical analysis section for the definition of COVID-19 severity stage. The overall sample had more than half of the patients in Stage B, one-third in Stage A, and just over one-tenth in Stage C which is the most critical stage. Staging showed statistically significant variation with Aseer having higher percentages in both stage A and C than other regions or the sample and Jazan also having a higher percentage in stage A. On the other hand, Bisha had 80% in stage B with only ⅓ as many in stage C, and Najran reflected the total sample. The other regions had more distribution between Stages A and B, Jazan and Najran had approximately half in Stage B while Aseer had approximately one third in Stage B. Jazan and Najran had approximately one third in Stage A, while Aseer had less than half in Stage A. In regard to the outcomes of the overall sample, 66% were eventually discharged to home, 25% died while in hospital and 9% were transferred to another facility. Outcomes showed statistically significant differences between regions, discharges to home were highest in Bisha at 84%, with Jazan at 67%, Aseer at 56%, and Najran at 45% ($p<0.001$). The overall hospital mortality rate was 25% but showing significant variation with the rate in Najran highest at 1.5 times the sample and Jazan and Aseer equal to the sample, while Bisha's was approximately half the sample ($p<0.001$). Transferals to a second facility showed significant variation across regions occurring in Najran and Aseer approximately 1.5 times as frequently as the overall sample which was less than one-tenth of the time. Transferals occurred in Jazan less than half as frequently as the overall sample and only one patient in Bisha was transferred ($p<0.001$). In regard to the clinical course, in the total sample, approximately half were admitted to ICU. ICU admission rates were 67% in Najran, 68% in Aseer, 40% in Jazan, and 31% in Bisha, a statistically significant difference ($p<0.001$). The mean LOS of the total sample was 11.13± 9.5 days but varied significantly across regions. Mean LOS was longest in Najran (15.1 ± 9.6 days) and Aseer (13± 9.8 days), shortest in Bisha (7 ± 8.6 days) and (10.5 ± 7.5) days in Jazan ($p<0.001$). Finally, COVID-19 complications showed statistically significant regional differences. Sepsis rates were 20% in the total sample, 30% in Najran, 24% in Aseer, 17% in Jazan, and 12% in Bisha ($p<0.001$). Bacterial pneumonia rates were 65% in the total sample, 97% in Bisha, 65% in Najran, 53% in Aseer, and 13% in Jazan ($p<0.001$). ARDS rates were 32% in the total sample, 44% in Najran, 39% in Aseer, 32% in Jazan, and 17% in Bisha ($p<0.001$). Arrhythmia rates were 4% in the total sample, 18% in Najran, 5% in Jazan, 2% in Bisha, and 1% in Aseer (<0.001). Acute kidney injury rates were 15% in the total sample, 21% in Najran, 19% in Aseer, 12% in Jazan, and 7% in Bisha ($p<0.001$). The final complication with statistically significant variation was multi-organ failure with rates of 18% in the total sample, 28% in Aseer, 20% in Najran, and 7% in both Jazan and Bisha ($p<0.001$).

## Discussion

The results of our multicenter comparative descriptive study have revealed some significant variations in the healthcare experience of COVID-19 inpatients among the southern regions in the KSA. We examined the data for 809 inpatients with COVID-19 reported to the Saudi Ministry of Health (MOH) from eight hospitals for a period of 12 months from March, 2020-February, 2021. We described patient demographics, clinical characteristics, and outcomes and compared them among Bisha, Jazan, Najran, and Aseer. This study revealed that of the overall sample from the regions of the proposed SBU of hospitalized patients with COVID-19, three-fourths were male and Saudi with a mean age of 60 years (Table 1). Of the overall participants 31% were in stage A, 56% were in stage B, and 13% were in stage C of COVID-19 severity at hospitalization (Table 2). Approximately half of the participants had diabetes, hypertension, or obesity and 15% had cardiac diseases. Approximately 1% had a history of cancer or being immunocompromised (Table 1). In regards to outcomes as shown in Table 2, the mean length of stay (LOS) was 11 days, two thirds were discharged to home, one fourth died in hospital, less than one tenth were referred to other facilities, and approximately half were admitted to an ICU. Table 2 illustrates the participants' complications arising from COVID-19 infection in descending frequency as bacterial pneumonia in two-thirds, ARDS in one-third, and sepsis, multi-organ failure, and acute kidney injury in one-fifth or less.

Significant statistical variation in demographic characteristics was evident among the participants in the four regions of the proposed Southern BU ($p<0.05$). Najran had the oldest mean age, while Jazan had the youngest mean age. Jazan and Najran had the highest percentage of Non-Saudi inpatients, while Bisha had the lowest. Additionally, when comparing the regions there was statistically significant variation in regards to comorbidities such as DM2, HTN, cardiac disease, and obesity, all of which have been shown to be risk factors for severe COVID disease and death.[1,9,21–24] Participants in the Najran region had the highest prevalence of DM2, HTN, and cardiac disease, in the Aseer region had the highest prevalence of obesity, and in the Jazan region had the highest prevalence of immunocompromise. On the

**Table 2** Clinical Course, Outcomes, and Complications of COVID-19 Inpatients by Regions in Southern KSA

| Characteristics | Frequency (n and %) | | | | | Chi-Square or #One Way ANOVA |
|---|---|---|---|---|---|---|
| | **Total N (%)** | **Jazan N (%)** | **Najran N (%)** | **Bisha N (%)** | **Aseer N (%)** | |
| | **809 (100%)** | **98 (12%)** | **120 (15%)** | **267 (33%)** | **324 (40%)** | ***p. value*** |
| **Clinical course and outcomes** | | | | | | |
| Stage at admission | | | | | | |
| Stage A | 255 (31.0%) | 38 (39.0%) | 40 (33.0%) | 41 (15.0%) | 136 (42.0%) | <0.001*** |
| Stage B | 450 (56.0%) | 47 (48.0%) | 67 (56.0%) | 214 (80.0%) | 122 (38.0%) | |
| Stage C | 104 (13.0%) | 13 (13.0%) | 13 (11.0%) | 12 (5.0%) | 66 (20.0%) | |
| Discharge home | | | | | | |
| No | 277 (34.0%) | 32 (33.0%) | 66 (55.0%) | 42 (16.0%) | 137 (42.0%) | <0.001*** |
| Yes | 532 (66.0%) | 66 (67.0%) | 54 (45.0%) | 225 (84.0%) | 187 (56.0%) | |
| Refer to another facility | | | | | | |
| No | 736 (91.0%) | 94 (96.0%) | 101 (84.0%) | 266 (99.6%) | 275 (85.0%) | <0.001*** |
| Yes | 73 (9.0%) | 4 (4.0%) | 19 (16.0%) | 1 (0.4%) | 49 (15.0%) | |
| Death in hospital | | | | | | |
| No | 609 (75.0%) | 72 (73.0%) | 73 (61.0%) | 226 (85.0%) | 238 (73.0%) | <0.001*** |
| Yes | 200 (25.0%) | 26 (27.0%) | 47 (39.0%) | 41 (15.0%) | 86 (27.0%) | |
| ICU admission | | | | | | |
| No | 387 (48.0%) | 59 (60.0%) | 40 (33.0%) | 184 (69.0%) | 104 (32.0%) | <0.001*** |
| Yes | 422 (52.0%) | 39 (40.0%) | 80 (67.0%) | 83 (31.0%) | 220 (68.0%) | |
| Duration of stay in days, mean (SD) | 11.1 (±9.5) | 10.54 (±7.5) | 15.1 (±9.6) | 7.30 (±8.6) | 13.00 (±9.8) | <0.001#*** |
| **Complications** | | | | | | |
| Sepsis | | | | | | |
| No | 648 (80.0%) | 81 (83.0%) | 84 (70.0%) | 236 (88.0%) | 247 (76.0%) | <0.001*** |
| Yes | 161 (20.0%) | 17 (17.0%) | 36 (30.0%) | 31 (12.0%) | 77 (24.0%) | |
| Bacterial pneumonia | | | | | | |
| No | 286 (35.0%) | 85 (87.0%) | 42 (35.0%) | 8 (3.0%) | 151 (47.0%) | <0.001*** |
| Yes | 523 (65.0%) | 13 (13.0%) | 78 (65.0%) | 259 (97.0%) | 173 (53.0%) | |
| ARDS | | | | | | |
| No | 554 (68.0%) | 67 (68.0%) | 67 (56.0%) | 222 (83.0%) | 198 (61.0%) | <0.001*** |
| Yes | 255 (32.0%) | 31 (32.0%) | 53 (44.0%) | 45 (17.0%) | 126 (39.0%) | |
| Arrythmia | | | | | | |
| No | 774 (96.0%) | 93 (95.0%) | 98 (82.0%) | 261 (98.0%) | 321 (99.0%) | <0.001*** |
| Yes | 35 (4.0%) | 5 (5.0%) | 22 (18.0%) | 6 (2.0%) | 3 (1.0%) | |
| Acute kidney injury | | | | | | |
| No | 691 (85.0%) | 86 (88.0%) | 95 (79.0%) | 247 (93.0%) | 263 (81.0%) | <0.001*** |
| Yes | 118 (15.0%) | 12 (12.0%) | 25 (21.0%) | 20 (7.0%) | 61 (19.0%) | |
| Hepatotoxicity | | | | | | |
| No | 795 (98.0%) | 94 (96.0%) | 116 (97.0%) | 265 (99.0%) | 320 (99.0%) | 0.073 |
| Yes | 14 (2.0%) | 4 (4.0%) | 4 (3.0%) | 2 (1.0%) | 4 (1.0%) | |

(*Continued*)

**Table 2** (Continued).

| Characteristics | Frequency (n and %) | | | | | Chi-Square or #One Way ANOVA |
|---|---|---|---|---|---|---|
| | Total N (%) | Jazan N (%) | Najran N (%) | Bisha N (%) | Aseer N (%) | |
| | 809 (100%) | 98 (12%) | 120 (15%) | 267 (33%) | 324 (40%) | *p. value* |
| GIT perforation | | | | | | |
| No | 803 (99.0%) | 97 (99.0%) | 117 (97.0%) | 367 (100.0%) | 322 (99.0%) | 0.066 |
| Yes | 6 (1.0%) | 1 (1.0%) | 3 (3.0%) | 0 (0.0%) | 2 (1.0%) | |
| Multi-organ failure | | | | | | |
| No | 666 (82.0%) | 91 (93.0%) | 96 (80.0%) | 247 (93.0%) | 232 (72.0%) | <0.001*** |
| Yes | 143 (18.0%) | 7 (7.0%) | 24 (20.0%) | 20 (7.0%) | 92 (28.0%) | |

**Notes**: Results were offered as frequency (number (n) and percent (%)). Correlation between variables was evaluated using the chi-square test. ***Significant difference at p ≤ 0.001; #*p*. value based on one way ANOVA test for continuous variables.

other hand, the lowest prevalence of diabetes and obesity were in the Jazan region, HTN, and immunocompromise was in the Bisha region, and cardiac diseases were in the Bisha and Aseer regions.

There was statistically significant variation of clinical course and outcome, including stage at admission, rate of discharge to home, referral to another facility, death in hospital, ICU admission, and LOS among the four regions of the proposed Southern BU (p<0.05). An evaluation of the severity of COVID-19 at admission revealed that participants in stage C, classified as critical by the MOH were highest in Aseer, those in stage B, classified as severe by the MOH were highest in Bisha and Najran respectively, and those in stage A, classified as mild to moderate by the MOH were highest in Jazan. Clinical course and outcome may be used as quality indicators during admission.[8,16,17] Aseer and Najran were almost identical, and had the highest prevalence among inpatients in rates of ICU admission, length of stay, and referrals to other facilities. The mortality rate had the highest prevalence in Najran followed in order by Aseer, Jazan, and Bisha. In contrast the Bisha region scored best in most of the quality indicators including the highest discharge to home and lowest prevalence of mortality, ICU admission and referrals to other facilities. Bisha also had the second lowest LOS after Jazan.

Statistically, significant variation occurred among the four regions of the proposed Southern BU (p<0.05) in complications that developed during admission. Najran had the highest prevalence of most complications (sepsis, ARDS, arrhythmia, acute kidney injury, and multi-organ failure), while Bisha had the highest prevalence of bacterial pneumonia. Conversely, Bisha had the lowest prevalence of ARDS and acute kidney injury, while along with Jazan the lowest prevalence of arrhythmia and multi-organ failure.

The variations in clinical and quality indicators among the four regions are explained in Tables 1 and 2. For example, the fact that Najran had the highest rate of mortality and referrals to other facilities and second-highest ICU admission and LOS might be explained by the participants in Najran being highest in the comorbidities of DM2, HTN, and cardiac disease as well as being second-highest in obesity. Moreover, although the majority of patients in Najran were admitted in stage B severity, they had the highest rates of complications acquired during admission including sepsis, ARDS, arrhythmia, and acute kidney injury. Additionally, Aseer had the second oldest patient group, was highest in obesity and second highest in most other comorbidities, which might explain the highest rate of ICU admission and LOS along with the second-highest rate of mortalities and referrals to other facilities. Aseer had the highest number of patients admitted in Stage C which might explain its second-highest rate of most complications during admission including sepsis, ARDS, arrhythmia, and acute kidney injuries. In contrast, Bisha showed the lowest rate in mortalities, ICU admissions, and referrals to other hospitals, along with the second shortest LOS all of which may possibly be explained by Bisha's position as the second-youngest group, lowest in HTN and cardiac disease, and second-lowest in obesity and DM2. Moreover, Bisha had the highest percentage of patients admitted in stage B severity but had the lowest incidence of most complications acquired during admission including sepsis, ARDS, and acute kidney injuries and notably in spite of the highest prevalence of bacterial pneumonia, the lowest mortality rate which may indicate quality of care.

The explanation of our findings in regard to outcome is consistent with several studies that reported the association of mortality with comorbidities, especially the risk factors of HTN, obesity, DM2, renal disease, and cardiovascular disease.[8,16,17,28–33] This study is also consistent with national studies that reported the association of complications of COVID-19, with mortality rate, ICU admission, and LOS[8,16,17] and our data is consistent with international studies that found significantly higher risk of death in COVID-19 inpatients with pre-existing obesity and complications of sepsis and multi-organ failure.[34,35] Other studies have found risk factors that have an impact on the severity of COVID-19 including certain demographics such as being male or of advanced age along with comorbidities such as DM2, HTN, cardiac diseases, asthma, chronic obstructive pulmonary disease (COPD), tuberculosis, pneumonia, ARDS, renal disease, and hepatic disease, along with behaviors such as smoking.[36,37]

Future research is needed to examine the distribution of cases in a healthcare crisis such as the COVID-19 pandemic as presented in a Johns Hopkins study encouraging the redistribution of both demand and resources in such a situation[11]. Future research at the regional, healthcare system, and facility levels is urgently needed to assess differences in socio-demographics, healthcare quality, and both human and non-human allocation of resources that may have contributed to the causes of the significant variation in severity and outcomes. Moreover, further studies should cover other proposed business units to compare them with each other to produce a whole workable picture for the healthcare system in the KSA and to simulate the new MOC with its transformations and reforms. As we observed obvious variation among the four regions, we suggest other studies to include multi-level variables including the structure of the health system in each region such as the level of human and non-human resources, process, and appropriateness of the provision of health services for patients, and finally including patient variables, and with these details it will be possible to know what we need in each region to cope with the goals of a newly transformed health care system under the Vision 2030 provisions.

## Strengths and Limitations

One significant strength of this study was the twelve month length of time for which the data was collected as most previous studies have been for very short time periods. In contrast, using a one year period provides a more accurate picture. Another strength is that this is the first study to describe and compare the four southern administrative regions which are proposed to form the Southern Business Unit under Vision 2030 of the KSA in relation to care of COVID-19 inpatients, which will provide a baseline for other studies to build on. Additionally, this is a multi-center study giving it a high degree of validity. This study is also distinguished by its multitude of variables, therefore, the findings potentially serve as a baseline for healthcare quality differences that must be considered when assessing BU performance under the new MOC of Vision 2030.

We must also illuminate certain limitations of this study. Firstly, factors other than those included in our study such as infrastructure or staffing may account for regional variations in the severity of COVID-19. Secondly, the cross-sectional nature of our research limits the relationship between variables and therefore any claim of causality. Finally, we are lacking a comparator group without COVID-19, however, this does not diminish the significance of our findings of variation between the regions which is our purpose.

## Conclusion

We observed variations in several aspects of COVID-19 inpatients among the four regions of the Southern BU. Participants in Najran and Aseer had the poorest outcomes with the highest mortality, ICU admission, and complication rates. The severity of COVID-19 disease, may be partially explained by the distribution of risk factors and characteristics with Najran and Aseer also having the oldest mean ages and the highest rates of most comorbidities. On the other hand Bisha had the lowest mortality, ICU admission, and complication rates with the exception of bacterial pneumonia and inspite of having the highest bacterial pneumonia rate still had the best outcomes. Jazan followed Bisha in outcomes. These results coincide with the data showing Bisha and Jazan had the youngest mean ages and lowest rates of comorbidities. The quality of care for COVID-19 inpatients has been impacted by the region in which a patient is hospitalized. As these variations span patient age, comorbidities, clinical course, complications, and outcomes it is clear that the task for the future is to mitigate any differences in the quality of healthcare between regions. We have made several recommendations in the discussion portion of this paper.

## Abbreviations

KSA, Kingdom of Saudi Arabia; CI, confidence interval; OR, odds ratio; ICU, intensive care unit; HTN, hypertension; MOH, Ministry of Health; ARDS, acute respiratory distress syndrome; GIT, gastrointestinal tract.

## Ethics Approval and Consent to Participate

Institutional Review Board Statement: Hospitals who reported the data to the MOH obtained, and the Clinical Excellence General Directorate of the MOH owned the data provided based on ethical approval from The Central Institutional Review Board of the MOH for providing the ethics review number IRB- log No: 20-163E. Informed Consent Statement: Data were taken from the Clinical Excellence General Directorate of the MOH Data Availability Statement: The data presented in this study are available on request from the corresponding author.

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The authors declare no conflicts of interest in this work.

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