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Epidemiological determinants for the spread of COVID-19 in Riyadh Province of Saudi Arabia



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ABSTRACT

Background and objective: Coronavirus Disease 2019 (COVID-19) has affected millions of individuals all over the world. In addition to the patients' compelling indications, various sociodemographic characteristics were identified to influence infection complications. The purpose of this study was to assess the impact of the aforementioned parameters on the dissemination of COVID-19 among residents of Saudi Arabia's Riyadh region.

Materials and methods: In the Saudi Arabian province of Riyadh, a cross-sectional retrospective analysis of COVID-19 incidences, recoveries, and case-fatality ratio (CFR) was undertaken. The study was carried out by gathering daily COVID-19 records from the ministry of health's official websites between October 2020 and September 2021. The influencing factors were obtained from the statistical authority. Using the SPSS IBM 25 software, the data was examined. The association between demographic factors as well as the presence of comorbidity on the COVID-19 outcome was determined using Spearman's correlation and regression tests. $P < 0.05$ was considered to indicate the significance of the results.

Results: The data from the study indicated that the highest number of COVID-19 cases were recorded in June 2021, and peak recovery was observed in July 2021. The CFR declined progressively from October 2020 to just over 1, even when the cases peaked. A significant ($p < 0.05$) correlation between diabetes and COVID-19 incidences was observed. The recovery rate had a significant ($p < 0.05$) association with the literacy rate and those aged 14–49 years old. Presences of co-morbidities such as Dyslipidemia, hypertension, diabetes, asthma, stroke and heart failure have negatively affected the recovery from COVID-19 in the population. The CFR is significantly ($p < 0.05$) associated with people over 60, hypertensive patients, and asthma patients. Regression analysis suggested that the risk of complications due to COVID-19 infection is more in males, people above 60 years age and those suffering from co-morbidities.

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Conclusions: The findings of the study indicate an association between several of the characteristics studied, such as gender, age, and comorbidity, and the spread of infection, recovery, and mortality. To restrict the spread of COVID-19 and prevent its complications, effective measures are required to control the modifiable risk factors.

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1. Introduction

Saudi Arabia is the largest country in the Gulf region. It comprises vast deserts, mountains, valleys, and forests. The population of the country is unevenly distributed. Large cities attract more people of different races, regions, and nationalities (El-Nesr et al., 2010). Riyadh is the capital of Saudi Arabia and is located approximately 600 m above sea level on the rocky plateau. The climatic condition of the city is extremely hot in summer and cold in winter (Weather information of Saudi Arabia, 2021). The city has the largest human population and is comprised mostly of Saudi citizens. The non-Saudis mainly include people from India, Pakistan, Bangladesh, Egypt and Yemen. Small proportions of Philipians, Europeans and Americans have also settled in this place (Mineta et al., 2021). The Riyadh population is quite young, the males outnumber the females, and the average size of the family is 5–6 members. The city has numerous healthcare centers, some of which are among the best in the Gulf. Similarly, the city hosts some of the most prestigious educational institutions in the country (Mineta et al., 2021).

Severe acute respiratory syndrome coronavirus-2 (SARS-CoV-2) is the cause for COVID-19 (coronavirus disease 2019). Normally, the infection causes mild to moderate symptoms resembling the seasonal flu (Abubakar and Aina, 2016). However, in a few individuals, it can also produce complications and even death. Several factors have been suggested for the occurrence of complications, such as age, gender, race, and co-morbid conditions of the population (Zhou, 2020). Currently, there is no specific treatment for COVID-19 and the approved medications basically used to control the symptoms. Drugs having antiviral, anti-inflammatory, anticoagulant and antihyperlipidemic properties are being used to manage the complications (Rothan and Byrareddy, 2020). The virus has specific structural components that could be considered as targets for medical interventions. Among these, spike proteins are considered important since they are involved in binding the virus to the host cells. Research has been underway to target this protein so that the virus loses the ability to bind the host cells (Sanders et al., 2020).

Riyadh, the largest city in the country, also recorded a greater number of COVID-19 cases. The reports of COVID-19 positive cases started from March–April 2020 (Walls, 2020). Earlier studies have demonstrated that the density of the human population and socio-economic factors directly contribute to COVID-19 transmission (Alharbi et al., 2021). Studies have indicated that the literacy rate can influence the public awareness that is essential for minimizing infection transmission (Sharifi and Khavarian-Garmsir, 2020). Gender-wise analysis suggested a high rate of COVID-19 incidence in males compared to females (Al-Zalfawi et al., 2021). The health status of the population is also reported to play a role in the pathogenesis of COVID-19. The complications of COVID-19 were found in people suffering from metabolic, cardiovascular, and immunological disorders (Wang et al., 2020).

The available data suggests that the urban lifestyle of Riyadh has played a role in several metabolic diseases such as obesity, hypertension, and diabetes mellitus (Yue et al., 2020). In addition, respiratory diseases and CNS disorders have also increased in the population (Al-Quwaidhi et al., 2014; Alamri et al., 2020). Analyzing the transmission dynamics in different settings can provide important information about the advancement of a pandemic,

and the data can be useful for healthcare providers in preparing proactive measures to reduce infection severity. As a result, the current study was designed to assess the epidemiological parameters that may have supported COVID-19's spread in Saudi Arabia's Riyadh area.

2. Materials and methods

2.1. Study design

A cross-sectional retrospective study in the Riyadh province of Saudi Arabia was conducted during the period between October 2020 and September 2021. Since the rate of COVID-19 infection fluctuated between months (Al harbi et al., 2021), the study was conducted for a duration of one year to avoid any discrepancies in data collection, analysis and determine the role of epidemiological factors on the COVID-19 outcome (Mishra and Tripathi, 2021). Official and published information about the ministry of health in Saudi Arabia was retrieved from websites such as MOH (<https://www.moh.gov.sa/en/Pages/default.aspx>), COVID-19 Dashboard (<https://covid19.moh.gov.sa/>) and Waqeya (<https://covid19.cdc.gov.sa/>). The daily reports of confirmed COVID-19 cases, recoveries and mortalities were entered in the excel sheet. The reverse transcriptase polymerase chain reaction (RT-PCR) technique was used to diagnose COVID-19 when patients visited the designated and approved COVID-19 testing centers (Walls, 2020). The study was conducted after obtaining the ethical clearance from the Research committee of College of Pharmacy (MCST/COP#20/2021), AIMaarefa University, Riyadh, Saudi Arabia.

2.2. Study setting

The study was conducted in the Riyadh region, which is also the capital city of Saudi Arabia. The city has the largest population, comprised of different nationalities. Saudi citizens constitute most residents (71.4%). The non-Saudis include people from India, Pakistan, Bangladesh, Egypt, Sudan, Yemen, and many other countries. The percentage of males (56%) was found to be more than the percentage of females (44%), and the literacy rate was estimated to be 92% (Mineta et al., 2021).

2.3. Data collection

Epidemiological data such as population size, age, gender, nationality, family status, place of residence and literacy rate was collected from the General Authority of Statistics, Kingdom of Saudi Arabia. The prevalence of diseased conditions in the population was collected from the ministry of health's web resources as well as from published articles. Daily records of COVID-19 cases detected, recovery rate and deaths were retrieved from the previously mentioned official and authorized websites of the country.

2.4. Analysis and representation of data

The daily record of COVID-19 in the Riyadh province from October 2020 to September 2021 was entered in the excel sheet. Similarly, the epidemiological parameters of the region were recorded,

and the analysis of the data was separately represented graphically as follows.

2.4.1. Infection rate and rate of recovery from COVID-19

The total number of infections and recoveries were recorded in different months to indicate the spread of infection and its outcome (Walls, 2020).

2.4.2. The Case-Fatality ratio (CFR)

This value was calculated from the formula described by Onder et al., 2020.

$$\text{(Total number of deaths} \times 100) / \text{Total number of cases} = \text{CFR}$$

2.4.3. Epidemiological parameters

Information available from various resources was summarized and the data such as the ratio of males to females, Saudis to non-Saudis, family status, literacy rate, and age-groups of the population were represented. The health status of the people of Riyadh province was indicated as the percentage of diseased conditions.

2.5. Data analysis

The recorded data was subjected to descriptive analysis to indicate the spread of COVID-19 infections in different months, the recovery rate, and case-fatality ratio in the Riyadh region. The data was correlated with epidemiological parameters of the region to determine the influence on the spread and outcome of COVID-19 (Onder et al., 2020).

2.6. Statistical analysis

To determine the association between COVID-19 and the various predictors, a 95% confidence interval was computed for all the epidemiological characteristics. Statistical analysis of the data was done using the SPSS IBM 25 software. Then Spearman’s correlation test was used to determine the association between gender, nationality, family status, literacy rate, age, and health status of the population with the COVID-19 outcome. To determine the influence of gender, age and co-morbidity on COVID-19, an adjusted logistic regression was performed using the outcome (alive or death) as a response variable (Ortiz-Prado et al., 2020). To specify the correlation, the data from these analyses were represented in tabular form. $P < 0.05$ was used to indicate the significance of the analysis outcome when compared with predictors.

3. Results

3.1. Infection and recovery rate due COVID-19 in Riyadh region

The data from Fig. 1 indicates total number of positive COVID-19 cases detected and number of recoveries found during different months in Riyadh province. From October 2020 the total number of COVID-19 cases started to decline and reached the lowest in December 2020. From January 2021 the COVID-19 cases again started to rise progressively and reached the peak in June 2021. The percentage increase from lowest to peak was found to be 1373%. And from July 2021 the total number of COVID-19 cases started to decrease again. The rate of recovery almost followed the graph of total number of cases. However, when the infection rate was raising, the recovery rate slightly lagged and when the infection rate started to decline, the recovery somewhat super-seeded it.

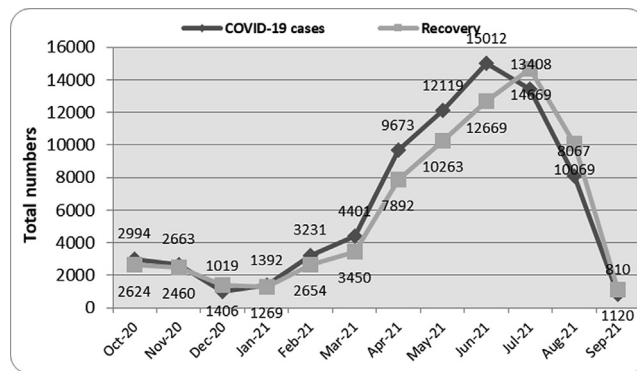


Fig. 1. Infection and recovery rate due to COVID-19.

3.2. Case-fatality ratio due to COVID-19

The case-fatality ratio graph indicated a progressive decline from October 2020. When the infection rate was increasing, the CFR did not show corresponding increase, rather it showed progressive decline. The highest CFR was found in October 2020 and then afterwards the CFR started to decrease. The lowest CFR was observed in May 2021 and from April 2021 the CFR remained ≈ 1 (Fig. 2).

3.3. Demographic characteristics of people residing in Riyadh region

Fig. 3 represents the demographic characteristics of Riyadh province. The data suggests that the region contains 56% males and 44% female population. Among them, 71.4% are Saudi citizens and 28.6% non-Saudi nationality people. 74.9% of the population live as nuclear family comprising of parents and off springs. The literacy rate of the Riyadh people was found to be 92%. The age-distribution analysis indicated that people having 15–34 years constitutes the largest group (33%), followed by 35–49 years old (29%), then 0–14 years (24%), 50–59 years (8.6%) and the least were above 60 years (4.2%).

3.4. Health status of people residing in Riyadh

The information from Fig. 4 suggests that the major diseased condition of the Riyadh region is diabetes mellitus. This metabolic disease is common among 39.4% of population, followed by dyslipidaemia (32.1%), hypertension (30.3%) and asthma (16.9%). Other health disorders such as coronary heart disease (2.5%), stroke (1.9%) and heart failure (1.2%) were also found in the population of this region.

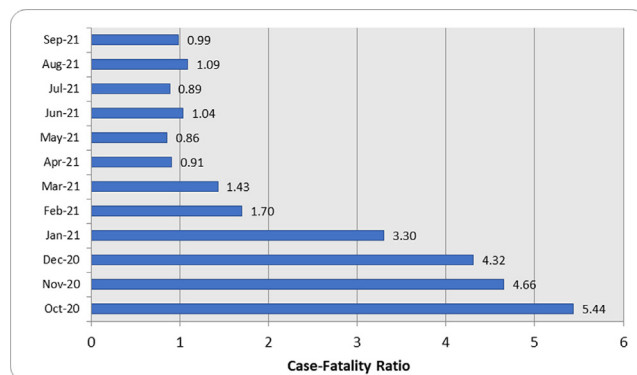


Fig. 2. Case-fatality ratio due to COVID-19.

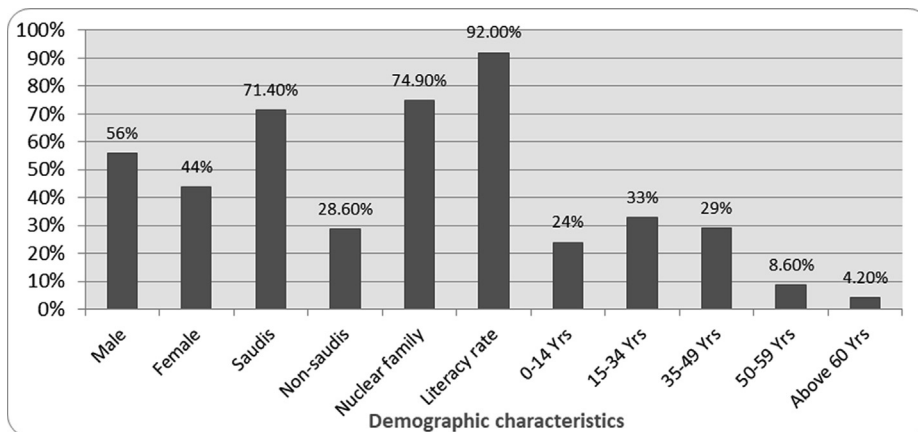


Fig. 3. Demographic characteristics of Riyadh province.

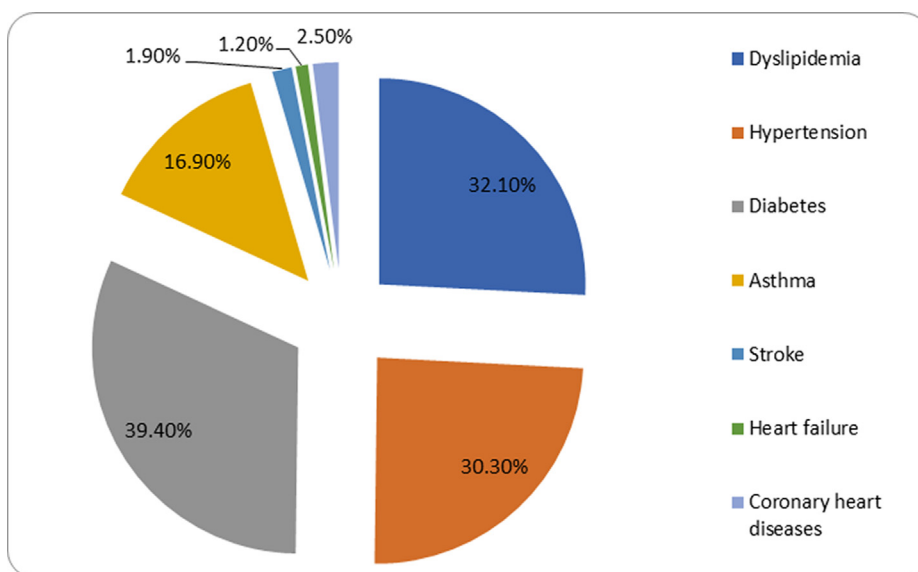


Fig. 4. Diseased condition of population of Riyadh.

3.5. Analysis of correlation between epidemiological parameters and COVID-19

The association between epidemiological characteristics of the population and the COVID-19 is represented in Table 1. The demographic characteristics indicated non-significant association between them and COVID-19 except gender. Here, the male population found to have the significant positive association ($Rho = 0.442, p = 0.009$) with COVID-19 infection. The analysis further indicated that diabetes mellitus also has positive significant association ($Rho = 0.329, p = 0.029$) with the incidences of COVID-19 in the population. However other diseased conditions though showed positive association but were found to be non-significant.

The analysis of recovery rate indicated that the literacy ($Rho = 0.109, p = 0.044$), 15–34 years age ($Rho = 0.620, p = 0.010$) and 35–49 years age ($Rho = 0.207, p = 0.039$) has a positive correlation with recovery of the population from COVID-19. Further, the diseased condition data suggested that all the health disorders negatively and significantly affected the recovery except stroke and coronary heart disease. The correlation values for significant association were found to be dyslipidemia ($Rho = -0.207, p = 0.036$), hypertension ($Rho = -0.309, p = 0.050$), diabetes ($Rho = -0.294, p = 0.007$), asthma ($Rho = -0.412, p = 0.029$) and heart failure ($Rho = -0.501, p = 0.048$).

The association between the demographic characters to COVID-19 indicated a non-significant correlation except for above 60 years old population. In this group, the correlation analysis suggested a positive and significant association between age and the fatality ($Rho = 0.421, p = 0.034$). In the diseased states analysis, hypertension ($Rho = 0.514, p = 0.045$) and asthma ($Rho = 0.354, p = 0.008$) have positive and significant correlation. Other diseases have some level of positive association with COVID-19 fatalities, but the data was found to be non-significant ($p > 0.05$).

The adjusted logistic regression analysis was performed using the outcome (alive/death) as a dependent variable and the presence of gender, age, and co-morbidities of patient as covariate. Each variate has a reference, and the comparison was done to this value. The analysis of the data indicated that the risk in male population infected with COVID-19 significantly ($OR = 1.68, p < 0.05$) higher than females. Similarly, the risk of age above 60 years was found to be significantly ($OR = 2.03, p < 0.05$) higher than people < 60 years old. The presence of co-morbidities was also found to increase the risk of death significantly ($OR = 3.93, p < 0.05$) compared to the people without the comorbid conditions (Table 2).

Table 1
Summary of correlation between COVID-19 and epidemiological parameters.

Epidemiological parameters		Confirmed COVID-19 cases				Recovery from COVID-19				Case-Fatality ratio due to COVID-19			
		Rho	P value	95% CI		95% CI	P value	95% CI		Rho	P value	95% CI	
				Lower	Upper	Lower	Upper	Lower	Upper			Lower	Upper
Demographic characteristics	Male	0.442**	0.009	0.096	0.167	0.069	0.152	0.098	0.114	0.175	0.239	0.071	0.256
	Female	0.0106	0.354	0.084	0.123	-0.018	0.083	0.239	-0.156	0.029	0.154	0.066	0.164
	Saudis	0.0158	0.412	-0.254	-0.147	0.009	0.069	0.086	0.176	0.052	0.087	-0.025	0.084
	Non-Saudis	-0.068	0.098	0.149	0.269	0.082	0.203	-0.099	-0.263	0.084	0.073	-0.063	0.294
	Nuclear family	0.098	0.229	0.109	0.088	0.054	0.174	0.197	0.329	0.002	0.078	0.058	0.162
	Literacy rate	-0.074	0.156	0.209	0.159	0.109*	0.044	0.088	-0.109	-0.244	0.088	0.091	0.244
	0–14 Yrs	0.065	0.081	0.184	-0.064	0.008	0.096	0.096	0.134	-0.023	0.258	-0.083	-0.127
	15–34 Yrs	0.0291	0.078	0.068	0.189	0.620**	0.010	-0.211	0.196	0.054	0.394	0.095	0.159
	35–49 Yrs	0.098	0.158	0.146	0.195	0.207*	0.039	0.069	0.118	0.119	0.157	0.094	0.213
	50–59 Yrs	-0.169	0.084	-0.069	0.143	0.056	0.059	-0.176	0.249	0.254	0.095	0.109	0.290
Above 60 Yrs	0.287	0.064	0.170	0.264	-0.128	0.168	0.098	0.186	0.421*	0.034	-0.186	0.072	
Diseased conditions	Dyslipidemia	0.146	0.093	0.088	-0.139	-0.207**	0.006	0.169	0.233	0.268	0.071	0.095	0.246
	Hypertension	0.087	0.384	0.115	0.186	-0.309*	0.050	0.054	0.128	0.514*	0.045	0.260	-0.163
	Diabetes	0.329*	0.029	-0.206	-0.197	-0.292**	0.007	-0.098	0.149	0.081	0.129	0.096	0.122
	Asthma	0.112	0.082	0.023	0.297	-0.412*	0.029	0.063	-0.084	0.354**	0.008	-0.069	-0.231
	Stroke	0.081	0.462	0.096	0.142	-0.252	0.095	0.259	0.124	0.268	0.147	0.091	0.143
	Heart failure	0.075	0.712	0.211	-0.036	-0.501*	0.048	-0.139	0.205	0.268	0.296	0.039	0.269
	Coronary heart disease	0.104	0.090	0.168	0.274	-0.289	0.246	0.097	0.182	0.462	0.093	0.224	0.181

Statistics: Spearman’s correlation test. * $p < 0.05$, ** $p < 0.01$; CI: Confidence interval.

4. Discussion

The present study evaluated the epidemiological determinants of the spread of COVID-19 in the Riyadh province of Saudi Arabia. The study analysed the spread, recovery, and case-fatality ratio. It also evaluated the association of epidemiological factors such as gender, age, race, literacy, and disease conditions of the population with COVID-19 (Figs. 1 to 4 and Table 1-2).

Data from the study indicated that the rate of infection showed a decline from October 2020 to December 2020 and then increased till June 2021, again declined from July 2021. The corresponding recovery rate followed the pattern of COVID-19 spread to a large extent, but when the infection rate was fast, the recovery slightly slowed down (Fig. 1). This pattern of infection and recovery rate was observed in other studies too. According to the findings of these studies, recovery from COVID-19 can take up to 6 weeks, depending on the severity of the disease, and thus the infection and recovery rates do not always coincide (Walls, 2020).

The correlation analysis indicated that the male population of Riyadh has a positive association (Rho = 0.442) with the COVID-19 spread (Table 1). This information supports the previous findings that the incidence of COVID-19 is higher in males compared to females (Al-Zalfawi et al., 2021). Several factors, such as the

extent of viral exposure and the presence of comorbid conditions in males, have been linked (Ortiz-Prado et al., 2020; de Souza et al., 2020). The correlation of diabetes in the Riyadh population and COVID-19 observed in the present study supports these findings (Table 1). Studies have also suggested that an individual’s chromosomal type plays a role in pathogenesis. The Y-chromosome population is more susceptible to infection than the X-chromosome population because their genetic make-up handles COVID-19 infection poorly when compared to X-chromosome people (Paz et al., 2020; Ortiz-Prado et al., 2021).

In addition, data from the present study suggests that there is a positive correlation between literacy rate (Rho = 0.109), 15–34 years age (Rho = 0.620) and 35–49 years age (Rho = 0.209) with the recovery rate from COVID-19 (Fig. 1 and Table 1). These findings agree with the previous data that suggested literacy increases the knowledge and awareness of the disease that might help in following the instructions of healthcare providers during treatment (Sharifi and Khavarian-Garmsir, 2020). The age of the population plays a role, and it was observed in the previous study that the immune system handles the infectious disease better in adulthood (Ortiz-Prado et al., 2020). Also, the co-morbidities in this stage of life are found to be relatively less and this might further boost the recovery from COVID-19 (Qin et al., 2020).

Table 2
Adjusted logistic regression using outcome (Alive/Death).

Risk factor for COVID-19	Parametric estimation	Odd ratio (OR)	Lower 95% CI	Upper 95% CI	p-value
<i>Gender:</i>					
Females (Reference)	-	-	-	-	-
Male	0.81	1.68*	1.65	2.48	0.044
<i>Age:</i>					
<60 years (Reference)	-	-	-	-	-
>60 years	0.98	2.03*	1.73	3.09	0.035
<i>Co-morbidity</i>					
No (Reference)	-	-	-	-	-
Yes	1.24	3.93**	1.46	2.39	0.009

Statistics: Logistic regression analysis. * $p < 0.05$, ** $p < 0.01$.

The correlation analysis further suggested that diseased conditions such as dyslipidemia ($Rho = -0.207$), hypertension ($Rho = -0.309$), diabetes ($Rho = -0.292$), asthma ($Rho = -0.412$) and heart failure ($Rho = -0.501$) negatively influence on the recovery rate. These diseases in the earlier studies were reported as the risk factors, and several mechanisms were suggested for the COVID-19 induced complications, which might delay the process of recovery. COVID-19 in dyslipidemia was found to cause more release of inflammatory mediators responsible for complications (Ryan and Caplice, 2020). The similarity in the association between COVID-19 and co-morbid conditions in Saudi Arabia is reported by Ejaz et al., 2020. The renin-angiotensin system was reported to be in a hyperactive state in hypertensive patients and SARS-CoV-2 selectively binds to the angiotensin converting enzyme-2 to enter the host cells, thereby increasing the infection rate (Alanazi et al., 2020). In chronic respiratory diseases such as asthma, the hypersensitivity responses to antigens, including SARS-CoV-2, are reported to trigger an exaggeration of inflammatory and pro-inflammatory cell activity (Wu et al., 2020). The heart failure condition is due to poor cardiovascular function that affects the functioning of vital organs, including the immune system, leading to complications (Qin et al., 2020).

The co-morbid conditions in the population has been reported to influence the severity of COVID-19 complications. The studies conducted on the COVID-19 patients have suggested that complications were highest in patients suffering from cardiovascular diseases (10.5%), followed by diabetes (7.3%), COPD (6.3%) and cancer (5.6%) (Alkhamees et al., 2020). Upon comparison, the mortality rate was found to be <1% in COVID-19 patients without any co-morbidities. The sickle cell anemia and pregnancy were also reported to increase moderately the risk of complications due to COVID-19 (Ali and Alharbi, 2020).

The case-fatality ratio analysis indicated a progressive decline from October 2020. Although the infection increased from January 2021 to June 2021, the CFR continued to decline (Fig. 2). This information suggests that the rate of fatalities per total number of recorded COVID-19 infections has decreased since October 2020 and can be attributed to the better management of viral induced complications (Sharifi and Khavarian-Garmsir, 2020). As per the ministry of health's documents, the country follows strictly the approved WHO guidelines for treating the COVID-19 and related complications. Moreover, the current data on the rate of vaccination in the Riyadh province has crossed over 70% (Saudi Ministry of Health, 2021). These measures adopted by healthcare providers could be responsible for the lower CFR in the population, although the infection rate peaked between April 2021 and June 2021.

The association of demographic factors further indicated a positive correlation between COVID-19 induced CFR and the above 60-year-old population ($Rho = 0.412$) (Table 1). Our data supports the earlier finding that the aged population is at risk of mortality, and the reason could be the presence of several co-morbid conditions associated with weak immune activity that make infection difficult to treat (Paz et al., 2020; Ryan and Caplice, 2020). Further, diseases such as hypertension ($Rho = 0.514$) and asthma ($Rho = 0.354$) have shown a positive relationship with CFR (Table 1). These conditions in the earlier findings augmented the incidences of mortality (Qin et al., 2020; Ryan and Caplice, 2020; Alanazi et al., 2020; Wu et al., 2020). As discussed earlier, hypertensive conditions increased the pathogenesis in the host system while, asthma produced hyper-inflammatory reactions to COVID-19, leading to increased chances of fatalities (Guan et al., 2020). In general, hyperactive inflammatory and pro-inflammatory mediators are suggested to be one of the important causes of COVID-19 induced complications in co-morbid patients (Alqahtani et al., 2020).

The present study established a correlation between some of the important epidemiological determinants such as gender (OR = 1.68), age (OR = 2.03) and co-morbidities (OR = 3.93) for COVID-19 in Riyadh province (Table 2). However, more research is needed in this direction to precisely understand the dynamics of COVID-19 in different groups of the population.

5. Conclusions

The data in this study indicated that the COVID-19 cases in Riyadh province reached a peak in June 2021 and the highest recovery was observed in July 2021. The case-fatality ratio showed a progressive decline since October 2020. The correlation analysis indicated a positive association between the male population and diabetic conditions with the incidence of COVID-19. The recovery was positively influenced by literacy level and the age of the population, and negatively correlated with some metabolic and respiratory diseases. The case-fatality ratio was found to have a positive correlation with people over 60 years old, hypertensive, and asthmatic people. More research involving different regions might provide clarity between the association of epidemiological factors and COVID-19 infection.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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