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Coronavirus Pandemic

COVID-19 pandemic in Saudi Arabia: an epidemiological analysis of 2020-2021

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Abstract

Introduction: The coronavirus disease 2019 (COVID-19) pandemic proved challenging for the healthcare systems. This study is an analysis of the epidemiological situation of COVID-19 in the Kingdom of Saudi Arabia (KSA), and the impact of the control measures on the epidemiological trends of the disease.

Methodology: A retrospective study was conducted on COVID-19 cases confirmed by reverse transcriptase polymerase chain reaction (RT-PCR) in KSA from March 2020 to December 2021. The numbers of confirmed, recovered, and death cases was analyzed and classified by age, gender, and nationality. Descriptive statistics and bivariate analysis for the disease trends and some of the control measures were conducted. All statistical analysis was carried out using the IBM SPSS version 26.

Results: There were 549,810 confirmed cases from March 2, 2020, to December 1, 2021. The highest number of cases was during the summer months. Men accounted for 70% of all reported cases. 65% of incidents involved people aged 20-50 years. Saudi nationals represented 63% of the total cases. There was a decline in both confirmed and fatality cases in 2021 compared to 2020 (OR = 2.1, $p < 0.001$; and OR = 2.53, $p < 0.001$ respectively). Furthermore, the precautionary measures implemented to curb the spread of COVID-19 had a positive effect in reducing disease incidences (correlation 0.75, $p < 0.001$).

Conclusions: The Saudi government has had exceptional success in controlling COVID-19 by expanding screening tests, launching immunization campaigns, and training physicians.

Key words: COVID-19; Saudi Arabia; epidemiology; prevalence; mortality; incidence.

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Introduction

The novel coronavirus (severe acute respiratory syndrome coronavirus 2, SARS-CoV-2) was detected in a series of instances of acute idiopathic pneumonia in Wuhan, China at the end of December 2019, and soon escalated into a pandemic [1]. Coronavirus disease 2019 (COVID-19), caused by SARS-CoV-2, was declared a public health emergency of worldwide concern by the World Health Organization (WHO) on January 30, 2020, with more than 213 nations reporting confirmed cases, including countries in Asia, Europe, and North America [2,3].

The Kingdom of Saudi Arabia (KSA) is considered a large country; the largest in the Middle East, second largest in the Arab world, and 13th largest globally (1.4% of global landmass), with an area of approximately 2.15 million km^2. It is also the 41st most populous country in the world, with a population of more than 37 million, or 0.46% of the world's population. The land area of KSA is divided into 13 administrative regions, including Al Baha, Al Jawf, Al Madinah, Al Qaseem, Al Riyadh, Aseer, the Eastern Region, Hail, Jazan, Makkah, Najran, the Northern Borders, and Tabuk (Figure 1) [4-6].

The first case of COVID-19 in KSA was reported on 2 March 2020, after which the Saudi authorities announced precautionary and preventive measures to prevent the spread of SARS-CoV-2 through human-to-human transmission. These measures included preparing hospitals to receive confirmed cases in all health sectors; conducting medical examinations at air and land ports; quarantining those suspected of being infected with the virus, specifically all those arriving at international ports; and conducting health awareness campaigns for citizens to educate them on the seriousness of the disease and prevention methods. The COVID-19 procedures and guidelines were communicated to all healthcare staff, and the epidemiological situation was monitored along with the WHO through the Command-and-Control Center of the Saudi Ministry of Health (MOH). During the pandemic, the country had also announced a ban on the entry of

foreigners into the kingdom for the purposes of Umrah, imposed restrictions on pilgrimages to holy places, and imposed a travel ban on people coming from countries affected by COVID-19 [6-8]. In fact, following the seven-year experience of dealing with Middle East respiratory syndrome coronavirus (MERS-CoV) in KSA, the health staff responded positively to the measures taken regarding the COVID-19 pandemic [9,10].

While the global pandemic was worsening, there was an increase in scientific research on the epidemiological trends of the disease. This helped us understand the nature of the disease, the associated risks, and ways of spreading; and this information supported the decision-makers when they developed appropriate policies and guidelines for epidemiological control [11,12]. Indeed, these strategies have taught us the importance of collaboration and rapid affirmative decisions in mitigating pandemics.

In this study, we used data associated with all confirmed COVID-19 cases in the KSA since the beginning of the outbreak in the country on 2 March 2020, until 1 December 2021, to describe the epidemiological situation and trends of the pandemic in the country and its administrative regions. We also analyzed the relationship between the control measures and their impact on the epidemiological trends of COVID-19. Our analysis may help in developing effective recommendations for COVID-19 control plans.

Methodology

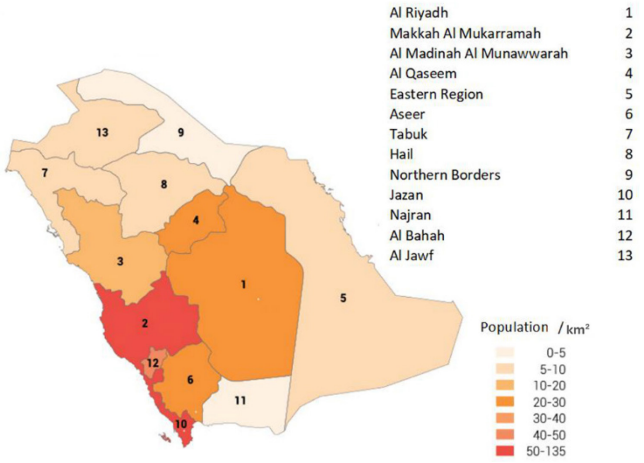
Data source and type of study

A retrospective investigation of all confirmed COVID-19 cases reported on the Saudi MOH, Saudi Center for Disease Prevention and Control, and WHO websites between 2 March 2020 and 1 December 2021 was conducted [13-19]. These sources provided daily statistics on COVID-19 incidences in KSA, including the following information: (a) number of newly confirmed cases; (b) number of fatality cases; (c) number of recovery cases; and (d) demographic information such as gender, age, and nationality (for the first 2 months), all of which were grouped by regions [13-21]. The WHO definition was used to define the COVID-19 cases as confirmed, fatality, and recovery [22].

Statistical analysis

IBM Statistical Package for the Social Sciences (SPSS) version 26 software (IBM Corp, Armonk, NY, USA) was used for statistical analysis. The data was subjected to a descriptive analysis for the COVID-19 pattern including population (age, gender, and nationality), time (months and years), and location (regions).

Figure 1. Distribution of population in the Kingdom of Saudi Arabia by regions (2017 Census).



The crude odds ratios (OR) were calculated for each variable of interest through bivariate analysis with 95% confidence intervals (CIs). The Pearson's correlation coefficient was calculated, whenever possible, to analyze the correlation of some factors on the trends of COVID-19, determine the strength of the associations and their direction, and determine the type of relationship. A + sign indicated a positive relationship, while a − sign indicated a negative relationship. The level of statistical significance was set at $p < 0.001$.

The prevalence was calculated using the following equation: $\mathrm{Pr} = \mathrm{nP.T} / \mathrm{N.T}$

where Pr = prevalence, nP.T = number of COVID-19 confirmed cases at one point in time, and N.T = total population of Saudi Arabia at the same point in time.

The case fatality rate (CFR, %) was derived using the following equation: $\mathrm{CRF\%} = \frac{nD.t}{nP.t} \times 100$

where nD.t = number of deaths from COVID-19 illness during a set period of time and nP.t = number of confirmed cases during that time. CFR is frequently used as a measure of illness severity and for prognosis (predicting disease course or outcome) [23].

Results

COVID-19 situation in KSA until 1 December 2021

COVID-19 trends in KSA

The first confirmed case of COVID-19 was reported in KSA on March 2, 2020, and the first case recovered from the disease was reported on March 12, 2020, followed by the first death on March 24, 2020.

KSA had reported 549,810 COVID-19 cases confirmed by reverse transcriptase polymerase chain reaction (RT-PCR), which accounts for approximately 1.6% of the Saudi population. In terms of the total number of COVID-19 cases, it was ranked 59th in the world (0.2% of all confirmed COVID-19 cases worldwide); and 22nd among Asian nations (0.68% of all confirmed COVID-19 cases in Asia).

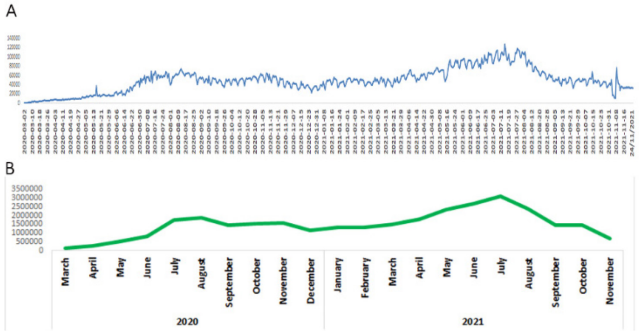
KSA had also registered 538,702 cases of recovery from COVID-19, accounting for recovery of 98% of COVID-19 confirmed cases and 0.23% of the recovered cases worldwide.

Moreover, KSA had reported 8,828 deaths due to COVID-19, and the CFR, which represents the severity of the illness, was 1.6%. KSA was placed 60th internationally with 0.17%, and 20th among Asian countries with 36% of COVID-19 deaths. The highest number of daily confirmed COVID-19 cases of 4919 cases was reported on June 16, 2020; while the highest number of fatalities in a single day of 58 deaths, was recorded on July 4, 2020. The highest number of recoveries in a single day was 7718 cases, and was recorded on July 13, 2020 (Figures 2A, B, C).

Screening for COVID-19

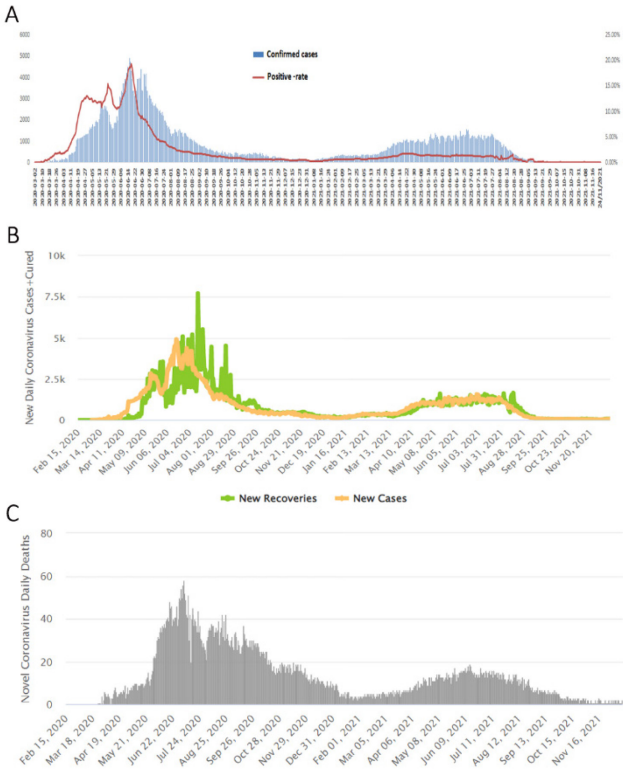
KSA had conducted COVID-19 tests on 31,100,182 persons (89% of KSA population) during our study period, at a rate of ≈ 887,291 tests per million; and the average number of tests per day was ≈ 49,328. Furthermore, 1.742% of these COVID-19 tests were positive. The highest daily number of screening tests was 117,221 on July 15, 2021. A total of 10,029,336 tests were done during the month of July 2021, which was the highest record of COVID-19 screening tests in a month and accounted for 21% of total tests in KSA; followed by August 2021. On the other hand, KSA accounted for 0.73% of all COVID-19 tests conducted worldwide, which ranked it 24th in the COVID-19 tests (Figure 3A, B).

Figure 3. Screening tests for COVID-19 (y axis) in the Kingdom of Saudi Arabia.



A: daily tests from beginning of outbreak until December 1, 2021; B: monthly screening tests from beginning of outbreak until December 1, 2021.

Figure 2. Trends of COVID-19 in the of Kingdom Saudi Arabia.

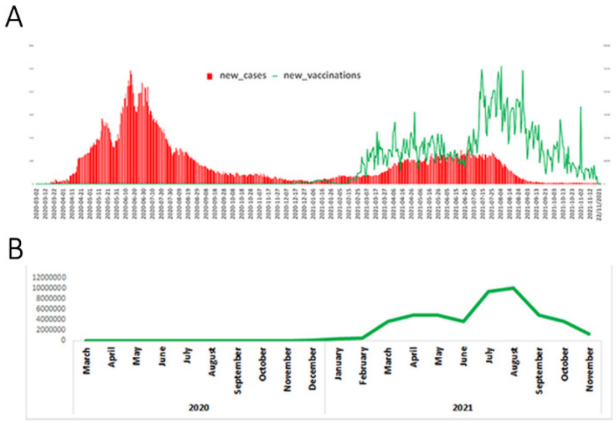


From the beginning of outbreak until December 1, 2021: A: daily confirmed cases and positivity rate; B: daily confirmed cases and recoveries; C: daily deaths.

COVID-19 vaccination campaign

The COVID-19 vaccination campaign in KSA started on December 17, 2020, and 47,304,122 vaccine doses were administered until December 1, 2021. There were 590 vaccine distribution centers, and 63.25% of the population (22,145,984 individuals) received both doses, while 6.27% (2,195,341 individuals) received only the first dose. The vaccination rate in Saudi Arabia was 35,459 doses per day, equivalent to 134.5 doses per 100 people a day. The maximum daily number of vaccinations during the research period was 511,131 doses on August 5, 2021. 16% (4,878,058) of all vaccinations were administered in August 2021, which was the highest number of COVID-19 vaccinations in a month. This was followed by July 2021. KSA had planned to administer two doses of the vaccine to 70% of the population by January 2022 at that time and ranked 20th in the world based on the number of people who received the vaccine. Four COVID-19 vaccines – Pfizer-BioNTech (Pfizer Inc, New York, U.S.A.), Moderna (Moderna Inc, Cambridge, U.S.A.), Oxford-

Figure 4. Vaccinations against COVID-19 and new cases in the Kingdom of Saudi Arabia between December 17, 2020, and December 1, 2021.



A: daily vaccinations; B: monthly vaccinations.

AstraZeneca (Astrazeneca PTY Ltd, North Ryde, Australia), and Janssen (Janssen Pharmaceuticals Inc, Titusville, U.S.A.) – had been approved in KSA at that time (Figure 4A, B).

COVID-19 infection pattern in Saudi Arabia until 1 December 2021

COVID-19 trend by region

The Al Riyadh Region had the largest number of confirmed COVID-19 cases, accounting for 23.9% (131,615) of all confirmed cases in KSA; followed by Makkah Al-Mukarramah Region at 23.8% (130,695); whereas the Al-Jawf Region had the lowest number of confirmed cases with 0.5% (2,709) of all confirmed cases.

Regarding COVID-19 fatality, Makkah Al-Mukarramah Region had the highest mortality rate, accounting for 36.1% (3,191) of the total fatalities in KSA, followed by Al Riyad Region at 17.8% (1,571), and Al Bahah at 1.1% (95) of the total deaths. Al Riyadh Region had the most recoveries from COVID-19,

Figure 5. Trends of total COVID-19 cases, recovery, and deaths in the Kingdom of Saudi Arabia by regions from beginning of outbreak until December 1, 2021.

accounting for 24.1% (129,797) of the total number of recoveries in KSA, followed by the Makkah Al-Mukarramah region with 23.6% (127,057); whereas Al-Jawf Region had the lowest number of recoveries with 0.5% (2,587) of the total number of recoveries in KSA (Table 1, Figure 5).

By calculating both the disease prevalence rate to measure the expansion of the disease in the region and the CFR to measure the disease severity within the region, it was discovered that Al Jawf Region had the highest CFR of 4.47%, despite having the lowest disease prevalence rate of 0.36%. On the other hand, Al-Madinah Al-Munawwarah region had the lowest CFR of 0.80%, and the Eastern region had the highest prevalence of 2.34% (Figure 6).

Figure 6. Case fatality rate (CFR, %) and prevalence of COVID-19 in the Kingdom of Saudi Arabia by regions from beginning of outbreak until December 1, 2021.

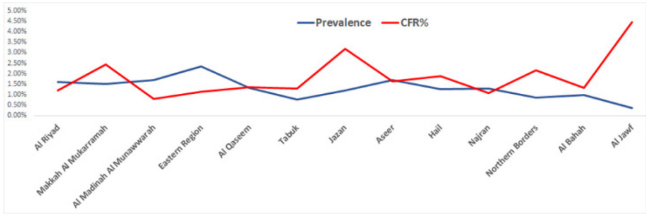


Table 1. Confirmed cases of COVID-19 until 1 December 2021 by regions.

No.	Region	COVID-19 Cases	Recovered	Deaths	Population	Prevalence	CFR %
1	Al Riyad	131615	129797	1571	8253723	1.59%	1.19%
2	Makkah Al Mukarramah	130695	127057	3191	8576927	1.52%	2.44%
3	Al Madinah Al Munawwarah	39564	39019	316	2332059	1.70%	0.80%
4	Eastern Region	117872	116380	1343	5032242	2.34%	1.14%
5	Al Qaseem	21700	21216	291	1639619	1.32%	1.34%
6	Tabuk	8600	8371	111	1142545	0.75%	1.29%
7	Jazan	21178	20365	675	1785303	1.19%	3.19%
8	Aseer	40994	40140	675	2415795	1.70%	1.65%
9	Hail	11735	11446	222	936242	1.25%	1.89%
10	Najran	10724	10529	114	820955	1.31%	1.06%
11	Northern Borders	5250	5024	114	610858	0.86%	2.17%
12	Al Bahah	7174	7035	95	718007	1.00%	1.32%
13	Al Jawf	2709	2587	121	749139	0.36%	4.47%
Total		549810	538966	8839	35013414	1.57%	1.61%

CFR: case fatality rate; COVID-19: coronavirus disease 2019.

COVID-19 infection rates by time

In the two years of study, 2020 and 2021, June 2020 had the highest number of confirmed COVID-19 incidents in KSA, accounting for 29.6% of the total confirmed cases compared to the other months. The winter months (October 2020-February 2021) had the fewest COVID-19 cases compared to the rest of the year (Figure 7).

COVID-19 incidence by population (gender, age and nationality)

Based to the information provided on the Saudi MOH website, COVID-19 incidences between March and August 2020, were analyzed based on gender. Males had the highest infection rate, accounting for 70% of confirmed cases, while 30% of the confirmed cases were women. 65% of the confirmed cases were in adults, aged 20-50 years; 20% of the cases were in individuals < 20 years old; and 15% of the cases were in individuals > 50 years old. Saudi citizens had the greatest infection rate, at 63%.

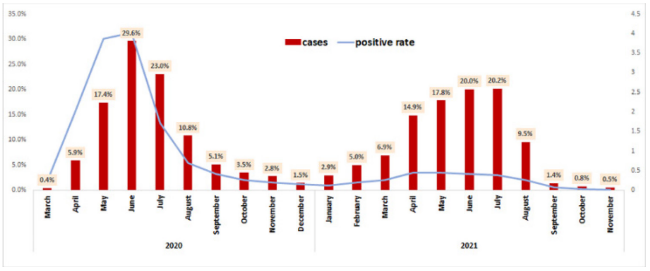
COVID-19 trends analysis

In 2020, a total of 356,740 persons (1.02% of Saudi Arabia's population) had COVID-19 confirmed tests, while 34,656,674 were disease-free. However, in 2021, a total of 171,650 (0.5%) individuals had COVID-19 confirmed cases and a total of 34,841,764 were disease-free. In fact, the OR of COVID-19 confirmed cases in 2020 was 2.1 times higher than that in 2021 (95% CI: 2.1059-2.1304) ($p < 0.001$).

In terms of deaths, a total of 5,908 (1.66%) COVID-19 patients died in 2020 and 350,832 (98.34%) recovered. In 2021, a total of 2,342 (1.36%) COVID-19 confirmed patients died, and 169,308 (98.64%) recovered. Indeed, the OR of COVID-19 death cases in 2020 was 2.53 times higher than that in 2021 (95% CI: 2.4202-2.6640, $p < 0.001$) (Table 2).

There was also a significant positive relationship between the increase in COVID-19 confirmed cases and the increase in COVID-19 deaths, and the Pearson's correlation coefficient was 0.756 ($p < 0.001$) (Supplementary Figure 1).

Figure 7. Temporal pattern of COVID-19 in the Kingdom of Saudi Arabia by months from beginning of outbreak until December 1, 2021.



COVID-19 trends analysis by region

In terms of COVID-19 deaths, Al Jawf had a higher CFR than the other 12 regions, with 121 (4.67%) deaths and 2,588 recovered patients. The OR of COVID-19 deaths in Al Jawf was 2.80 times higher than the other regions (95% CI: 2.703-2.910, $p < 0.001$). In terms of disease spread, the Eastern Region had 2.34% greater COVID-19 prevalence than other regions, and the OR of COVID-19 prevalence in the Eastern Region was 1.6 times higher than other regions (95% CI: 1.732-2.802, $p < 0.001$).

The results showed that the higher number of physicians in one region was reflected in the higher number of recoveries from COVID-19 in that region; and it was confirmed statistically by Pearson's correlations, which showed a strong positive and statistically significant relationship between the number of physicians in the regions and the number of recoveries from COVID-19 with correlation coefficient of 0.880 ($p < 0.001$; Table 3, Supplementary Figure 2).

Preventive measures and COVID-19 trends

There was a significant negative relationship between vaccination and COVID-19 deaths, as the increase in vaccination corresponded with decrease in COVID-19 deaths, and the correlation coefficient was -0.237 ($p < 0.001$). Similarly, vaccination was correlated with fewer COVID-19 positive cases, with a correlation coefficient of -0.272 ($p < 0.001$) (Supplementary Figure 3).

Regarding the preventive measures, policy responses, reported on Our World in Data as the

Table 2. Descriptive statistics of COVID-19 in Saudi Arabia.

	Descriptive Statistics									
	N	Minimum	Maximum	Sum	Mean		Skewness		Kurtosis	
	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Std. Error	Statistic	Std. Error
Cases	638	1	4919	548286	874.46	37.938	1.799	0.098	3.247	0.195
Recovery	616	0	7718	538702	856.97	37.18	1.799	0.098	3.247	0.195
Deaths	628	0	58	8828	14.09	0.523	1.267	0.098	1.428	0.195
Tests	638	260	117221	31100182	49328	159.52	0.245	0.098	0.042	0.195
Vaccinations	305	0	511131	22145984	35459	289.937	2.723	0.098	4.6	0.278

COVID-19: coronavirus disease 2019; Std. Error: standard error.

Stringency Index (measure based on 9 response indicators including school closures, workplace closures, and travel bans; rescaled to a value from 0 to 100 [100 = strictest response]), of the confirmed COVID-19 cases in the KSA showed that there was a statistically significant positive relationship between the increase in incidences of the disease and the increase in the responding precautionary measures taken against it with a Pearson's correlation value of 0.750 ($p < 0.001$) until the date of December 1, 2020. The month of April 2020 had the highest level of precautionary measures at a value of 93 in the Stringency Index (Supplementary Figures 4 and 5).

Discussion

Our research investigated the epidemiological trends of COVID-19 in KSA, including confirmed cases, recovery rates, and mortality rates. The main finding of the outbreak analysis was that there was more than a 40% decline in cases from the first month (1500 confirmed cases, 0.27% of all reported cases), to the last month (866 confirmed cases, 0.16% of all reported cases).

The total number of COVID-19 confirmed cases was two times fewer in 2021 than it was in 2020, and the number of fatalities was 2.5 times lower. Our study intended to identify the most significant factors that contributed to this decline. The findings also revealed that the Saudi government's efforts to control the illness intensified in tandem with the rise of verified COVID-19 cases. These actions included increasing awareness, disinfecting to reduce viral spread, proclaiming a state of emergency, imposing a curfew, prohibiting public meetings, school closures, workplace closures, and travel bans. At that time, KSA allocated over 11,000 hotel rooms to accommodate nationals returning from overseas for quarantine or treatment. This eventually led to a decrease in infection and helped limit the spread of the virus [6,24].

Our study's findings also revealed that COVID-19 mortality in KSA was significantly lower than in other affected countries, which might be attributed to the fact that the majority of the infections were documented in adults between the ages of 20-50 years. In general, KSA is considered as one of the youngest countries, with more than half of its population under the age of 50 years, as evidenced by an increase in the recovery rate and a decrease in the number of deaths, which is consistent with the fact that the Kingdom has a young population [3,25].

KSA had begun countrywide vaccination efforts against COVID-19 on 17 December 2020, which was one of the most important contributors to the dramatic drop in confirmed cases and deaths caused by COVID-19. Our research found a direct and significant link between vaccination, confirmed cases, and deaths, as high vaccination rates were reflected in a lower rate of confirmed cases and deaths due to COVID-19; thus, confirming the importance of vaccination in combating, and controlling the COVID-19 pandemic in KSA.

Table 3. Distribution of total number of physicians by regions in Saudi Arabia.

No.	Region	Total Physicians
1	Al Riyad	23220
2	Makkah Al Mukarramah	20210
3	Al Madinah Al Munawwarah	5697
4	Eastern Region	15244
5	Al Qaseem	3874
6	Tabuk	2408
7	Jazan	2664
8	Aseer	6182
9	Hail	2198
10	Najran	1757
11	Northern Borders	1292
12	Al Bahah	1551
13	Al Jawf	1972
Total		88269

KSA was also very active in early COVID-19 detection. Our findings showed that KSA had an 89% screening rate and ranked high globally in detecting the virus, demonstrating that thorough examinations significantly lower the number of fatalities. Therefore, more examinations can lead to the early detection and treatment of cases before complications occur [26,27]. Additionally, our findings showed a rise in positive cases in the summer, namely in August and July, and a decline in the winter. During the same months, our data also showed an improvement in vaccination rates and screening tests for early disease detection; as a result, fewer people died from the disease.

The epidemiological curve of the disease in various KSA regions was further clarified by our research, with the results showing a favorable and statistically significant correlation between a high concentration of physicians and an increase in the rate of COVID-19 recovery for a specific location. This was in line with the MacIntyre and Binkin study from 2021, which claimed that the lack of public health professionals advising governments contributed to the pandemic's growth [28].

Furthermore, the CFR of COVID-19 in Al Jawf region was the highest in KSA compared to other regions, which suggests that the presence of risk factors such as cold climate, can contribute to disease severity, or, more importantly, the presence of chronic diseases in patients with COVID-19 [29]. The findings also showed that the Eastern region had a higher disease

incidence than the rest of the kingdom, which could be due to risk factors such as the high population density; combined with a lack of adherence to preventive measures; as well as the greater density of malls, shops, restaurants, cafes, and children's playgrounds.

Conclusions

The robust public health measures of the KSA government have successfully managed outbreaks and pandemics such as MERS and COVID-19 and may help in preventing future pandemics. The preventative actions taken by KSA were successful in managing COVID-19, as evidenced by a considerable decline in confirmed cases. even though many countries were still in the pandemic stage. Several strategies were used by KSA to manage the COVID-19 pandemic, including early detection and surveillance through wide-screening tests, promotion of public awareness campaigns on the importance of vaccination, and strengthening public health infrastructure through increasing emergency response capabilities, and physicians' experience dealing with the disease. These strategies ultimately led to bringing the COVID-19 pandemic under control. Further investigations are needed to determine the factors that caused the increased numbers in men, and whether the increased number of cases during the summer were due to a lack of preventative measures or the nature of the disease. Additional epidemiological research in Al Jawf and the Eastern region is required to determine the risk factors that led to disparities in the severity and spread of the disease between these two regions and the rest of KSA.

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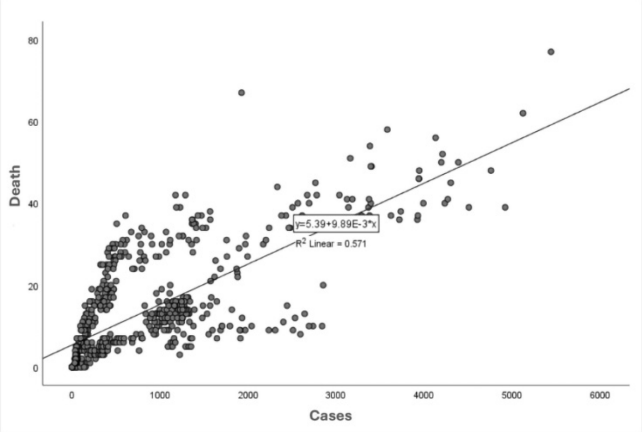
Conflict of interests: No conflict of interests is declared.

Annex – Supplementary Items

Supplementary Figure 1. Pearson's correlation demonstrates a strong and significant positive relationship between the increase in confirmed COVID-19 cases and the increased number of COVID-19 deaths from March 2, 2020, until December 1, 2021, ($p < 0.001$).

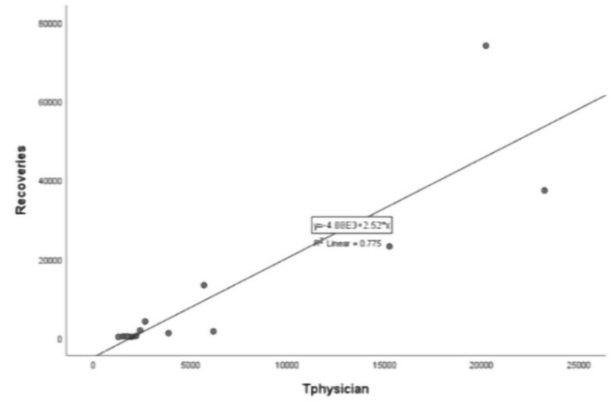


Supplementary Figure 2. Pearson's correlation indicates a strong and significant positive relationship between total physicians (Tphysicians) and COVID-19 recoveries in the regions from March 2, 2020, until December 1, 2021, ($p < 0.001$).

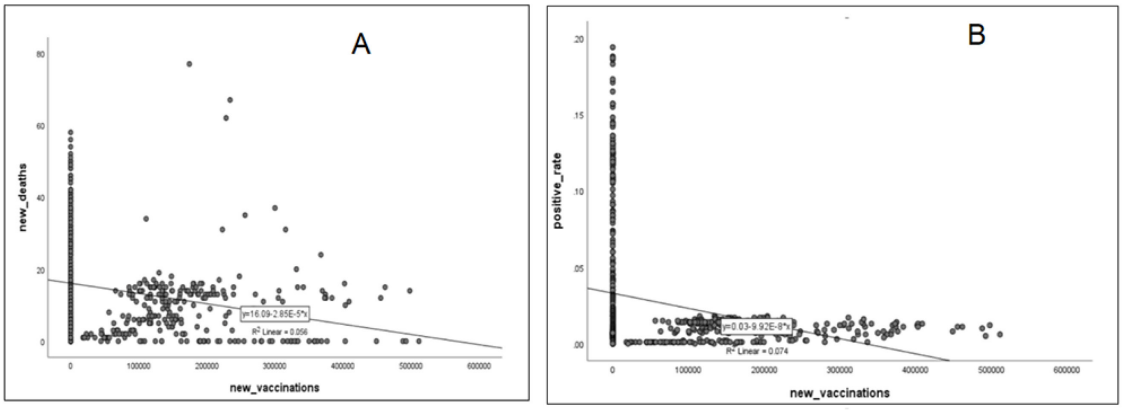
Correlations

		Tphysician	Recoveries
Tphysician	Pearson Correlation	1	.880
	Sig. (2-tailed)		.000
	N	13	13

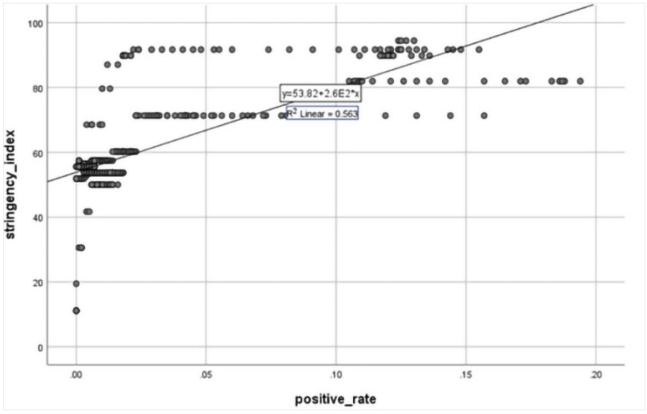
Graph



Supplementary Figure 3. Pearson's correlation shows a negative relationship between vaccination and (A) death, (B) positive rate of COVID-19 from December 17, 2020, until December 1, 2021, ($p < 0.001$).



Supplementary Figure 4. Pearson's correlation illustrates a positive relationship between positive rate and preventive measures (stringency index) from March 2, 2020, until December 1, 2021, ($p < 0.001$).



Supplementary Figure 5. Daily control measures (stringency index, y-axis) against COVID-19 from March 2, 2020, until December 1, 2021.