The current reproduction number of COVID-19 in Saudi Arabia: is the disease controlled?

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Abstract

The infectiousness of COVID-19 is high among the susceptible population, making the calculation of the reproduction number (R) an essential step to implement preventive measures. We aim to estimate COVID-19 transmission to determine if the disease is successfully controlled or extra measures should be adopted to attain this goal. The daily incidence data of COVID-19 in Saudi Arabia from March 2nd, 2020, to April 4th, 2021, were obtained from the continuously updated Saudi Ministry of Health COVID-19 repository. To get accurate estimation of the situation over the last 4 months (from December 1st, 2020, to April 4th, 2021), we calculated the weekly (every 7 days) R starting from March 2nd, 2020, and till the last week of the available data. The calculated values of R were represented as median, first quantile (Q_1), and third quantile (Q_3). As early as the first week of December 2020, the median R was 0.81 (0.80–0.83) which means that each existing infected case would transmit infection to only one person. This was followed by fluctuations over the next few weeks around R value of 1, reaching its highest level of 1.45 (1.42–1.47) between December 31st, 2020, and January 6th, 2021. This was followed by a relatively steady decline over the following weeks, with some till mid-March where the R values started to slightly rise again. Social distancing, protective precautions, avoiding abuse of the partial lifting, expanding the screening process, and other Saudi measures sound to be successful and should be replicated in similar communities. This measure should be continued till the vaccination process is completed, to reduce the number of contacts and to avoid uncontrolled transmission of the disease.

Keywords COVID-19 · Coronavirus · Saudi Arabia · KSA · ARIMA · Forecast

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Introduction

In December 2019, unexplained pneumonia was reported in Wuhan City in China. Searching for the cause of this unexplained pneumonia was the primary concern among Chinese clinicians. After performing clinical investigations, isolation of a virus related to the genus coronaviruses was done and later named the novel coronavirus (COVID-19) by the World Health Organization on January 12 (Imai et al. 2020). Chinese authorities have developed intense efforts for knowing the possible infectious source of COVID-19. The seafood market in Huanan was the primary origin of the virus and the transmission occurred from animals—commonly bats—to the human cases similar to other viruses of the corona family (Gralinski & Menachery). Like other respiratory illnesses, contact with respiratory droplets was the common route of COVID-19 for the human-to-human transmission (Guo et al. 2020). However, other routes of transmission such as fecal-oral and intrauterine were reported in the literature (Chen et al. 2020; Gu et al. 2020).

Since its discovery, the clinical symptoms and signs needed for the diagnosis of a COVID-19 case were the key issue among the clinical society especially with the similarity in symptoms with other respiratory illnesses such as a common cold. The incubation period of the virus varies among patients and ranged from 0 to 24 days (Guan et al. 2020a). Fever, dry cough, sputum production, shortness of breath, and diarrhea were the common presenting symptoms in COVID-19 cases. Moreover, in severe COVID-19 infection, neurological symptoms were frequently reported such as headache, dizziness, and impaired consciousness (Huang et al. 2020; Mao et al. 2020).

Isolation of the virus by the polymerase chain reaction (PCR) is the widely accepted approach for COVID-19 diagnosis; however, due to its limitation by reporting false-negative results, the clinical manifestations of the virus in addition to the characteristic abnormalities in the computed tomography (CT) are sufficient to the diagnosis of COVID-19 cases in case of false-negative PCR results (Ai et al. 2020; Li and Xia 2020).

Mortality from COVID-19 was likely to fall in the range of 2–7%, and the risk further increased with the advancement of age (due to the weak immunity), male sex, and patients identified with certain comorbidities such as hypertension, diabetes, cardiac disorders, chronic respiratory disease, and cancer (Caramelo et al. 2020). It is still unknown why some countries had high mortality compared to others; however, the high infectious power of the virus with the presence of asymptomatic carriers in addition to the report of the continuous mutation in the COVID-19 viral genome is the common presenting hypotheses that can explain the mortality difference among countries (Bai et al. 2020; Forster et al. 2020).

The infectiousness of COVID-19 is high among the susceptible population, making the calculation of the

reproduction number (R) an essential step to implement preventive measures (Alimohamadi et al. 2020; Huang et al. 2020). As an epidemiological metric, R is generally used to estimate the contagiousness of different infections. Simply, it represents the possible number of new cases caused by an infected individual (Delamater et al. 2019; Liu et al. 2020). In a previous meta-analysis, the pooled R for COVID-19 was estimated to be 3.32, which was not affected by the model type used (Alimohamadi et al. 2020). There is scarce evidence about the COVID-19 transmission rates in Saudi Arabia or how successful the adopted protective measures. For that, in the current study, we aim to estimate COVID-19 transmission to determine if the disease is successfully controlled or extra measured should be adopted to attain this goal. Additionally, we provide a summary of the ethical issues in the ICU admission process that may arise during pandemics.

Methods

Data collection

The daily incidence data of COVID-19 in Saudi Arabia from March 2nd, 2020, to April 4th, 2021, were obtained from the continuously updated Saudi Ministry of Health COVID-19 repository (Saudi Ministry of Health 2021).

Statistical methods

Using the obtained official daily new cases, we used the statistical framework suggested by Cori et al. to estimate R over the course of disease in Saudi Arabia using incidence time series (Cori et al. 2013). Following Fraser (2007), they assume that the distribution of infectiousness through time after infection is independent of calendar time. To do that, we used the ready-to-use tool provided by Cori et al. (2013), which “incorporates uncertainty in the distribution of the serial interval (the time between the onset of symptoms in a primary case and the onset of symptoms in secondary cases).”

To get an accurate estimation of the situation over the last 4 months (from December 1st, 2020, to April 4th, 2021), we calculated the weekly (every 7 days) R starting from March 2nd, 2020, and till the last week of the available data. The calculated values of R were represented as median, first quantile (Q_1), and third quantile (Q_3).

Results

As early as the first week of August, the median R was 80.81 (0.80–0.83) which means that each existing infected case would transmit the infection to only one person. This would mean that the disease is successfully contained with

transmission control. This was followed by fluctuations over the next few weeks around an R -value of 1, reaching its highest level of 1.45 (1.42–1.47) between December 31st, 2020, and January 6th, 2021. This was followed by a relatively steady decline over the following weeks, with some until mid-March where the R values started to slightly rise again (Table 1). Fig. 1 shows the median R (with 95% credible interval) and COVID-19 incidence in relation to the $R=1$ line.

Discussion

To our knowledge, this is the only updated study to show the current situation in Saudi Arabia. Our results show that the control measures in Saudi Arabia are paying off. The R is getting below 1, and it sounds to be the case for a considerable duration of time now.

Saudi Arabia was one of the countries that implemented early measures to avoid the introduction of the COVID-19 infection to the country and to mitigate its effect once it arrives (Algaissi et al. 2020). On February 6th, the Saudi government issued a flight ban for all direct flights from/to China (Duan et al. 2020). Moreover, all international Umrah pilgrims and tourists were banned from entry, followed by banning individuals from COVID-19-affected countries, on February 27th

and 28th, respectively (Algaissi et al. 2020). Despite these restrictions, the first case of COVID-19 was reported in Saudi Arabia on March 2nd, by a traveler who has concealed his travel history to Iran (Algaissi et al. 2020). On March 4th, the two holy mosques in Makkah and Madinah were completely closed along with a completed suspension of all Umrah activities (Algaissi et al. 2020). By March 12th, the Saudi government suspended all social and governmental gatherings with a subsequent suspension of all air flights, events, and workplaces (except for healthcare and security sectors) (Algaissi et al. 2020).

Till April 14th, the cases were around 500, which shows the efficacy of these combined measures, especially the 24-h curfew and lockdown on the cities of Riyadh, Tabuk, Dammam, Dhahran, and Hofuf and throughout the governorates of Jeddah, Taif, Qatif, and Khobar, imposed on April 6 (Arabi et al. 2020; Brouquet et al. 2018). With the extensive mass field testing, the discovered cases increased rapidly to exceed 1000 daily cases and stay that high till the moment (Brouquet et al. 2018; Guan et al. 2020b). This mass testing by the ministry of health may explain the rapid acceleration of the discovered cases and why our model predicted a doubling of these cases over the few upcoming weeks. On April 26th, the Saudi government decided to partially lift the curfew restrictions and to allow public movement from 9 a.m. until 5 p.m.,

Table 1 Estimates of the instantaneous reproduction number R

Time periods		Posterior R moments			Main R Quantiles					
Start	End	Mean	SD	0.025 quantile	0.05 quantile	0.25 quantile	Median	0.75 quantile	0.95 quantile	0.975 quantile
1-Dec-20	7-Dec-20	0.81	0.02	0.77	0.78	0.80	0.81	0.83	0.85	0.86
8-Dec-20	14-Dec-20	0.68	0.02	0.64	0.65	0.67	0.68	0.70	0.72	0.72
15-Dec-20	21-Dec-20	1.02	0.03	0.96	0.97	1.00	1.02	1.04	1.06	1.07
22-Dec-20	28-Dec-20	0.97	0.03	0.91	0.92	0.95	0.97	0.99	1.02	1.03
23-Dec-20	29-Dec-20	0.69	0.02	0.64	0.65	0.67	0.69	0.71	0.73	0.74
24-Dec-20	30-Dec-20	0.97	0.03	0.91	0.92	0.95	0.97	1.00	1.03	1.04
31-Dec-20	6-Jan-21	1.45	0.04	1.37	1.38	1.42	1.45	1.47	1.51	1.53
7-Jan-21	13-Jan-21	1.28	0.03	1.22	1.23	1.26	1.28	1.31	1.34	1.35
14-Jan-21	20-Jan-21	1.28	0.03	1.22	1.23	1.26	1.28	1.30	1.33	1.34
21-Jan-21	27-Jan-21	1.33	0.03	1.28	1.29	1.31	1.33	1.35	1.38	1.39
28-Jan-21	3-Feb-21	1.07	0.02	1.03	1.03	1.05	1.07	1.08	1.10	1.11
4-Feb-21	10-Feb-21	0.97	0.02	0.93	0.94	0.96	0.97	0.99	1.01	1.01
11-Feb-21	17-Feb-21	1.01	0.02	0.96	0.97	0.99	1.01	1.02	1.04	1.05
18-Feb-21	24-Feb-21	1.10	0.02	1.05	1.06	1.08	1.09	1.11	1.13	1.14
25-Feb-21	3-Mar-21	1.01	0.02	0.98	0.98	1.00	1.01	1.03	1.05	1.05
4-Mar-21	10-Mar-21	1.07	0.02	1.03	1.03	1.05	1.07	1.08	1.10	1.11
11-Mar-21	17-Mar-21	1.31	0.02	1.27	1.28	1.30	1.31	1.33	1.35	1.36
18-Mar-21	24-Mar-21	1.33	0.02	1.28	1.29	1.31	1.33	1.34	1.36	1.37
25-Mar-21	31-Mar-21	1.36	0.02	1.32	1.32	1.34	1.36	1.37	1.39	1.40
29-Mar-21	4-Apr-21	1.37	0.02	1.33	1.33	1.35	1.37	1.38	1.40	1.41

SD standard deviation, *R* reproduction number

Fig. 1 Median reproduction number (R), with 95% credible intervals, and COVID-19 incidence in relation to the $R=1$ line (X-axis points: 1 = 2-Mar-20; 51 = 26-Apr-20; 101 = 15-Jul-20; 151 = 4-Aug-20; 201 = 23-Sep-20; 251 = 12-Nov-20; 301 = 1-Jan-21; 351 = 20-Feb-21)

until May 13th. These recent decisions would have a possible impact on the COVID-19 situation in Saudi Arabia, especially if the individuals let their guards down and did not apply social distancing measures.

Over the past few months, the cases were fluctuating with alternation between increase and decline. As of September 4th, 2020, the total recorded cases were 346,047 cases; out of them, 332,550 recovered or discharged and 5348 passed away (Saudi Ministry of Health 2021), although the new cases have been decreasing in numbers and the death rate sounds to be declining in a similar way. Going forward on April 6th, 2020, the total recorded cases were 394,169 cases; out of them, 380,772 have recovered or discharged and 6,711 passed away (Saudi Ministry of Health 2021). As per the last available reports, there are 6686 active cases in Saudi Arabia (Saudi Ministry of Health 2021). Noteworthy, Saudi Arabia reported giving 5,345,625 doses of vaccination (Saudi Ministry of Health 2021), which should be reflected by further transmission control and getting the R below 1 over the next few weeks.

That said, the author would urgently suggest the need for a careful investigation of the recent rise in R -value, which may be a serious indicator. It may be a result of the loosening in the protective measure, whether by the government or the general population. If this was true, public health interventions and awareness campaigns should be implemented as soon as possible to uncontrolled transmission. Also, individuals should be encouraged to take the vaccines whenever possible, and any fears they may have should be relieved through the proper educational intervention on site or through the media.

Ethical consideration in ICU admission

It is well-known that during pandemics, the intensive care units (ICU) are usually overwhelmed by patients who had severe conditions that may require mechanical ventilation. The ethical dilemma towards who, when, and why the patients are preferred to enter ICU rather than the other remains a topic of discussion among several countries that had a limited capacity of ICU beds (Arabi et al. 2020). With an ICU admission rate of COVID-19 estimated to be 5% of infected patients, national policies should be initiated for identifying high-risk patients in addition to quarantine measures for limiting disease transmission that can induce more number of patients with more overwhelming of the medical system and staff (Guan et al. 2020b). From the patients' point of view, seeking justice in the medical service given to them is essential with an equal opportunity to each patient regarding his sex, race, occupation, marital, and socioeconomic status. However, the capacity of the medical service during pandemics forces the medical staff to choose who lives and who dies (Rothstein 2010). The choice of giving the medical service to the restricted number of patients should be calculated according to several perspectives: (1) younger patients are preferred over older patients as they have lower expectancy of life, (2) patients without comorbidity are superior to patients with comorbidity, (3) medical staffs are preferred compared to other professions as they have the capacity for saving more lives, and (4) less severe cases have more chance of living rather than severe ones.

Despite settling these criteria in many countries, a question has been raised about patients who had an equal chance of life: who will be chosen? Rothstein indicated that the patient who was first admitted to the hospital had the superiority to enter

ICU; however, this criterion is not appropriate as hospital admission may be delayed due to several circumstances such as the delay in transportation, information deficiency especially in comatose patients, and hospital-related issues such as financial obstacles (Rothstein 2010). In conclusion, the choice of who lives and who dies is much complicated in pandemic times; therefore, each country should provide ethical standards for medical staff to avoid high mortality rates in addition to providing justice in the medical service according to each population characteristic.

Conclusion

Social distancing, protective precautions, avoiding abuse of partial lifting, expanding the screening process, and other Saudi measures sound to be successful and should be replicated in similar communities. However, over the past few weeks, the R started to rise above 1, which may indicate some loosening in the protective measures and social distancing. Along with the wide vaccination campaign adopted by Saudi Arabia, strict precautions should be continued, with reducing the number of contacts, till the vaccination process is completed to avoid uncontrolled transmission of the disease.

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AA contributed to the design of the work, the acquisition, and interpretation of data; revised the draft; approved the final version of the manuscript; and agreed to be responsible for the quality and accuracy of all parts of the work.

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