The impact of the precautionary measures taken in the kingdom of Bahrain to contain the outbreak of COVID-19

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ABSTRACT
As a worldwide pandemic is unavoidable, its spread must be observed to reduce and contain it. The Kingdom of Bahrain sought to implement the World Health Organization (WHO) directives to take precautionary measures and appropriate preventive steps to limit the spread of the coronavirus among people and developed an integrated plan to contain it. This study purposes to investigate the effect of precautionary and preventive measures in limiting the spread of coronavirus in Bahrain. Statistics and the details of precautionary measures described in this study are obtained from websites maintained by the Ministry of Health (MOH) in Bahrain. The calculated number of infected and death cases is determined by using polynomial functions that fit the data. The outcomes obtained showed that the number of cumulative infected and death cases were less than the expected numbers except for certain periods. Reopening stores and businesses that provide direct services to people after their two-week closing resulted in a 36% increased in infected cases than expected in the closing period. When the lockdown continued, the number of infected people dropped to 64% of the total number of detected infections. In accordance with our results, it is expected that the number of infected cases will gradually decrease till late March 2021. With continuing lockdown and their compliance in implementing the precautionary measures with consciousness, it is anticipated that Bahrain will soon be in the final state of the epidemic.

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1. Introduction
On December 31, 2019, the World Health Organization (WHO) informed about a new virus, the COVID-19, responsible for respiratory disease in Wuhan, China (Chen et al., 2020). It stimulated great concern inside China as well as universally resulting in the virus’ spread and improvement patterns (Shao, Zhong, & Chen, 2020). COVID-19 has now spread widely across the world and WHO declared it as a pandemic in March 2020 (World Health Organization, 2020a; World Health Organization, 2020b).

COVID-19 has an incubation period of three to seven days and may last up to fourteen days, and this period varies from patient to patient (Wang, C et al. 2020). It is believed that the coronavirus is contagious during incubation period when patients do not have symptoms, and can be spread from one person to another by direct contact and through sneezing, coughing, or speaking (Ministry of Health, 2020a).

COVID-19 is caused by Respiratory Coronavirus Syndrome (SARS-CoV-2). The virus is believed to have entered Bahrain on February 24, 2020. On September 18, 2020, a total of 63189 confirmed cases have been reported, of which 56700 have recovered, and 220 have died, whereas 157 cases have been receiving treatment, 43 of which are in critical condition. Out of 6959 active cases, 6916 are in a satisfactory condition (Ministry of Health, 2020b; WHO, 2020).

Since the infection started to spread universally, Bahrain has shown its sincere commitment to keep up the health and well-being of its population. Additionally, it has demonstrated a high degree of readiness to stand up to this infection since its appearance in China. As a result, a wide range of decisions, precautionary measures, and preventive measures have been taken in Bahrain.

The government of Bahrain had made efforts to contain the virus and to reduce its spread to the broader population. Since the start of the pandemic, it has followed the WHO’s guidelines, implementing...
a strategic response plan that included tracking the contacts, increasing the preparedness of healthcare facilities, and finding ways to communicate with the target groups. The government also used many advanced technologies to follow up on the infected and quarantined and trace contacts (E Government, 2020).

People also participated in the National Campaign to Support Fight Against COVID-19 by staying in their homes and not going outside except for necessity, distancing themselves from society and avoiding interaction with others, not spreading rumors and misleading facts. Besides, respecting hygiene, hand washing, they adhered to the commitment to home quarantine after their travel (Ministry of Health, 2020c). The Ministry of Health (MOH) requires all citizens and residents to adhere to all the directives issued by the official authorities, represented in wearing masks, adhering to social distancing steps, washing hands regularly, and always using hand sanitizer. It also urges not to leave the house except when necessary to meet basic living needs.

A comprehensive national plan was developed for surveillance to confront the virus and to control its spread. A surveillance and control committee was formed in the Military Hospital to control the virus’ spread at the beginning of February 2020 to decide the protocols and to set strategies that must be followed by the citizens and residents of Bahrain.

Alumran (2020) showed that the COVID-19 pandemic can be controlled if drastic precautions are taken in the early phases of an outbreak in the affected area. Following the introduction of many preventive steps, the spread of COVID-19 has been brought under control in the neighboring Kingdom of Saudi Arabia.

In another study, Dowd et al. (2020) agreed that governments worldwide should take strict precautionary steps to prevent the pandemic of COVID-19. In addition, Xiao and Torok (2020) emphasized in their article that in the face of the rapidly spreading disease and many infected people, effective infection prevention and control measures are urgently needed.

Al Nasser (2020a) stated in his study that according to the reported models and assumptions, the number of actual cases of the COVID-19 in Bahrain is less than the expected cases in Wuhan by approximately 16.3 times. These results could be attributed to the National Coronavirus Response Team’s arrangements to tackle the COVID-19 epidemic in Bahrain.

This study tries to assess the effect of precautionary measures taken in Bahrain to contain the virus and determine the best of these measures in controlling the virus’s spread.

2. Method

The statistics of COVID-19 and the data for implementing precautionary measures were collected from the Ministry of Health (MOH) website in Bahrain (Ministry of Health, 2020c) and the website (Our world in data, 2020). The first case of COVID-19 appeared on February 24, 2020, and from that date to September 18, 2020, the data on the spreading epidemic was collected daily.

Statistics of the number of infected cases in Bahrain during this study are divided into five periods based on the precautionary measures that were followed during each period (see Table 2). The observed number of infected cases for each period—and their best-fit lines—are plotted using Microsoft Excel, where x refers to the number of days and y refers to the number of infected and the death cases. The polynomial functions defining the best-fit lines are obtained using the polynomial approximation available in Microsoft Excel. Using the derived polynomial functions, the expected number of infected and death cases are calculated. The average % rate of increase or decrease between the observed data of a certain period and the expected number of infected cases of its previous period is calculated using the formula:

\[
\text{Average % rate} = \frac{1}{n} \sum_{i=1}^{n} \left( \frac{O_i - E_i}{E_i} \right) \times 100
\]

where \(O_i\) is the observed number of cases on day \(i\), \(E_i\) is the expected number of cases on day \(i\) and \(n\) is the number of days.

3. Results

Up to September 18, 2020, the expected number of infected and death cases is expected to increase without precautionary measures. The polynomial function used for estimating the infected and death cases are given as

\[
y = 1.4858x^2 - 12.116x + 2024.6 \quad (1)
\]

and

\[
y = 0.0073x^2 - 1.1581x + 43.106 \quad (2)
\]

with \(R^2=0.9871\) and \(R^2=0.977\), respectively.

Figure 1 displays the observed number of cases infected with COVID-19 in Bahrain versus the estimated number when the protective measures are not implemented. Figure 2 shows the monitored number of death cases from COVID-19 in Bahrain versus the estimated number if the protective measures are not implemented. It is noticed that the numbers of detected infections and deaths are less than the estimated cases, except in some periods in
which the estimated cases are less than the detected ones.

From the first case of COVID-19, the Government Executive Committee has endeavored to work hard to control the extent of the virus in the people, and it imposed many precautions shown in Table 1. These strategies are based on the recommendations of the WHO.

Figure 3 shows the number of total infected cases during the periods of applying precautionary measures. The data is splitting into five categories: using social distancing, distance working and closing educational schools, closing commercial and industrial shops that provide goods directly to people for two weeks, reopening these shops for another two weeks, and re-closing them again for two weeks.

On the other hand, Figure 4 represents the number of infected and expected cases when using precautionary measures separately. It is noticed in Figure 4a that applying social distancing and the travel ban to some affected countries, between February 24 and March 13, had an unnoticeable impact on the expected numbers of infected cases. The average % rate of change in this period increased by 5% compared to the expected number of infected cases. The quadratic equation (3) was used to estimate the number of infected cases in this period:

$$ y = 0.6067x^2 - 4.3201x + 26.752 $$  \[(3)\]

During the next ten days, the National Medical Team for Responding to coronavirus issued directives for transitioning to the distance work, the suspension of studies in all educational institutions, closing of cinemas and sports centers and restricting the activities of restaurants to external requests only
During this period, the average rate of change of infected cases decreased by 18.68% compared to the expected infected cases when only social distancing and travel bans were implemented, as shown in Figure 4a.

In Figure 4b, from March 26 to April 9, a decision was issued to close commercial and industrial shops that provide goods directly to people. During this period, the average rate of change of infected cases increased by 12.4% compared to the expected numbers in case continuing with the previous precautionary measures. The quadratic equation that fits the curve of this period is given by

Table 1. The Precautionary measures applied to stop the spread of COVID-19 in Bahrain from the beginning of the pandemic until September 18, 2020 (Ministry of Health, 2020c).

| Date                  | Precautionary measures                                                                 |
|-----------------------|----------------------------------------------------------------------------------------|
| February 24-March 14  | • Social distance                                                                      |
|                       | • Travel ban to and from some affected countries by coronavirus                       |
|                       | • Quarantine and home isolation for people returning from travel.                      |
| March 15-March 24     | • Reducing the number of upcoming trips                                               |
|                       | • Distance working                                                                     |
|                       | • Closing all educational institutions                                                 |
|                       | • Closing of cinemas and sports centers                                               |
|                       | • Restrictions on restaurants to entertain only the external requests                  |
|                       | • Closing salons                                                                        |
| March 26-April 9      | Closing commercial and industrial shops that provide goods directly to people         |
| March 29- Farther notice| Random COVID-19 tests                                                                 |
| April 10-April 23     | Reopening commercial and industrial shops that provide goods directly to people        |
| April 23 - Farther notice| Wearing face masks is declared mandatory for everyone                             |
| April 24-May 7        | Closing commercial and industrial shops that provide goods directly to people         |
| May 8- Farther notice  | Reopening commercial and industrial shops that provide goods directly to people        |
| June 3- Farther notice | Mandatory wearing masks and imposing a fine on violators                              |
| August 6              | Reopening gyms and sports halls, swimming pools, and outdoor sports                    |
| September 3           | Outdoor dining at restaurants, coffee shops, and training institutions                 |

Table 2. The average % rate of change in infected cases at the different periods of applying the precautionary measures.

| Periods of the study | Precautionary measures                                                                 | Average % rate of increase or decrease in infected cases |
|----------------------|----------------------------------------------------------------------------------------|----------------------------------------------------------|
| Period 1             | Social distance                                                                        | 5%                                                       |
| Period 2             | Distance working and closing all educational institutions                               | -18.68%                                                  |
| Period 3             | Closing commercial and industrial shops that provide goods directly to people          | 12.14%                                                   |
| Period 4             | Reopening commercial and industrial shops that provide goods directly to people        | 36%                                                      |
| Period 5             | Closing commercial and industrial shops that provide goods directly to people          | 13.4%                                                    |

Figure 3. The number of total infected cases when the precautionary measures were applied from 24/2/2020.
Later, a decision was issued to open these shops, which led to an increase in the average % rate of change of COVID-19 cases by 36% compared to the numbers expected when applying the previous precautions, as shown in Figure 4c. The best fit curve used to compare the infected patients in the reopening period is given as

\[ y = 0.2858x^2 - 2.3039x + 3.8004. \]  
(4)

Two weeks later, the shops closed again, which led to a 13.4% increased in the average % rate of change in the infected cases than the expected infection in case continuing with the previous measures as shown in Figure 4d. The best fit curve used in this period is given as

\[ y = 0.3967x^2 - 0.7884x + 18.291. \]  
(5)

Figure 5 displays the number of infected cases when continuing with closing schools, educational institutions, shops, and sports centers, compared to the number of recorded infectious. If the lockdown phase continues, the number of infections will decrease with an average % rate of 64% than the expected observed infected cases.

The adherence shown by the people to wear masks had a significant impact in limiting the spread of the epidemic in Bahrain, as the number of expected infections when wearing masks was 14% less than the numbers estimated before the wearing of masks was made compulsory as shown in Figure 6.

Figure 7 shows that above 700 cases were observed after Eid-Al-Fitr, and after Ashura, the highest observed cases were on September 16, 2020, with more than 800 cases. The best fit curve for the daily infected cases is given as

\[ y = 0.014x^2 + 5.8968x - 110.47. \]  
(7)

Figure 7 also shows that the expected number of infected cases will gradually decrease during March,
**Figure 5.** The expected number of infected cases upon continuing the implementation of the lockdown compared to the number of real infected.

**Figure 6.** Number of infected cases when the masks are mandatory for citizens and residuals compared to the number of infected patients when the masks are not mandatory.

**Figure 7.** Number of daily infected cases and the expected number of cases.
April, and May. From this estimation, the epidemic in Bahrain is projected to end after 403 days from the starting day, which corresponds to late March 2021.

4. Discussion

This study aims to investigate the effect of Bahrain’s precautionary measures to stop the spread of COVID-19. The results support the tremendous effect of precautionary measures during the pandemic outbreak.

Since the first case of Covid-19 virus appeared in Bahrain, the Ministry of Health has called on all citizens and residents to implement social distancing. This measure had the effect of increasing the expected number of infected cases by 5% rather than decreasing it. A study that evaluated epidemic data in Spain, between February 24 and April 5, 2020, determined that physical distancing measures effectively controlled the spread of the disease (Saez, Tobias, Varga, & Barceló, 2020; Reis et al., 2020), especially when applied correctly and for an appropriate duration (Ambikapathy & Krishnamurthy, 2020). This increase in the infected cases had to be reduced, so the Ministry of Health called for the application of other measures (see Table 1).

Applying home quarantine to travelers at the beginning of the pandemic (see Table 1 and Figure 4a) has had a significant effect on controlling the virus’s spread, so the number of infections seemed to be roughly equivalent to the number predicted in case the measures were implemented. Similar to these results, Nussbaumer-Streit et al. (2020) reported in their review article that a combination of isolation and other prevention and control measures had a more significant impact than the quarantine alone. Also, Yuan, Li, Lv, and Lu (2020) reported that quarantine in Hubei Province has been effective in slowing the quick increase in new cases of COVID-19. Besides, Tang et al. (2020) proposed that it is essential to strengthen the quarantine and isolation strategy further in order to improve the detection rate in mainland China.

The closing of educational institutions, applying social distances, reducing the number of upcoming trips, distance working, closing cinemas and sports centers, restriction on restaurant activities to external requests, and closing salons is among the precautionary measures, which have had a significant impact on the reduction of infectious from the expected number. These steps were introduced after 21 days following the discovery of the first case of COVID-19 in Bahrain, leading to a decrease of 18% in the number of cases than expected. A study conducted in Korea (Kim, Kim, Peck, & Jung, 2020) showed that the Korean government would be able to reduce the number of infected cases by at least 200 if schools were closed earlier.

The policy requiring shops that provide direct services to residents to be closed for two weeks, then reopening them for another two weeks, and re-closing them for the next two weeks of the opening period. The implementation of these measures did not reduce the number of infected cases but instead increased them than the expected number by 12.14%, 36% and 13.4%, respectively.

During the first closure period, the number of infected cases was increased than what was expected when the previous measures continued to be applied due to the application of random testing, which revealed more cases since March 29 (Ministry of Health, 2020). Besides, during the second closure period, the number of infections increased more than the first closure period due to shops opening between these two closure periods (see Figure 4d). The results also show a rise in the observed cases at the time when shops are reopened (see Figure 4c). This increase could be due to people not adhering to preventive measures when leaving their homes, especially since this time precedes the holy month of Ramadan and Eid al-Fitr when people prepare to buy supplies, clothes, and so on. In addition to these reasons, people stranded in some affected countries were evacuated, which caused a growth in the number of cases.

In addition to the results obtained, it was found that the continued closure of shops leads to an apparent decrease in the number of projected infections. These results are consistent with the research in Italy, which showed the importance of closures in disease control (Chintalapudi, Battineni, & Amenta, 2020). Tobias (2020) and Saez et al. (2020) analyzed trends in Covid-19 confirmed and deaths cases in Spain and Italy before and after the national lockdown, using time-series statistics. Their results show that the trends in COVID-19 infection have decreased dramatically after applying the lockdown. The closures enable the health system to increase its ability to help and reduce disease transmission by about 60%, considering that it affects patients with or without symptoms (Anderson, Heesterbeek, Klinkenberg, & Hollingsworth, 2020). On the other hand, Xiao and Torok (2020) suggested that blocking traffic and villages lockdown is of no significance for the prevention and control of COVID-19.

The imposition of wearing face masks starting from June 3 has led to a decrease in the number of infected cases more than expected as in Figure 6. Similar to these result, a U.S. study provided evidence that states, where the use of masks was imposed, saw a significant drop in rates of Covid-19 infection, unlike other states where masks were not
set (Lyu & Wehby, 2020). Besides, Barasheed et al. (2016) systematically analyzed the use and efficiency of masks by integrating 12,710 samples from more than 50 countries. They discovered that wearing masks in crowded locations could reduce the risk of respiratory infection by 20%.

By adhering to the precautionary measures and not being complacent in their application, besides taking the vaccine against Covid-19 provided by Bahrain’s government, the number of infected cases will disappear at the late March 2021 (see Figure 7). On the other hand, Al Nasser (2020b) proposed that the end date of the COVID-19 pandemic in Bahrain, according to mathematical models, is August’s end. In his opinion, it will end in December 2020.

5. Conclusion
The Kingdom of Bahrain has taken several precautionary measures to curb the spread of COVID-19, starting with some lenient measures and ending with drastic measures. This study showed the impact of the precautionary measures on the cumulative number of infected cases in Bahrain. Detected infected cases were lower than expected throughout the study period, except for some periods, in which the number of infected were increased.

One of the precautionary measures that were applied and had a significant effect in reducing the number of detected infected was the lockdown. Bahrain witnessed a decrease in the number of infected during the closing of schools, salons, sports, and entertainment centers, as well as the distance work. The application of social distancing and the compulsory wearing of masks for all people resulted in a decrease in the number of cases. Continuing the lockdown phase will significantly impact in reducing the number of infections by 64% than the real observed cases. According to the statistics of the daily number of infected patients until September 18, 2020, the end of the epidemic will be on late March 2021.

COVID-19 can be controlled by applying and adhering to the precautionary measures. Everyone needs to join with others to wipe out the epidemic and take part with greater consciousness and dedication than ever before reducing the coronavirus spread.

Data availability statement
The data that support the findings of this study are openly available in “Our World in Data” at https://github.com/owid/covid-19-data/tree/master/public/data, (Our world in data, 2020).

Disclosure statement
No potential conflict of interest was provided by the author(s).

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