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LOCK DOWN AND MOVEMENT BAN STRATEGIES TO CONTROL NEW COVID-19 INFECTIONS: A CASE STUDY OF OMAN

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Abstract: Worldwide, COVID-19 has paralysed health and business, including many service and manufacturing sectors. In absence of an effective vaccine, control measures and strategies to suppress virus infections is important. This study investigates the effectiveness and significance of lockdown and movement bans implemented in the country to moderate and resist the spread of infection from the SARS-CoV-2. Data on lockdown, movement ban period, new confirmed cases, deaths and recovery rate records and statistical analysis with Spearman correlation is performed between the variables reference to the two subjects of study to understand the association and significant relationship to validate the findings. Lockdown was for 66 days and movement ban for 30 days. Average number of confirmed cases and deaths was more in movement ban phase with 4252.7 and 89.6 respectively. The IFR % and CFR % were 6% and 4% ,reaching peak levels in August during the movement phase. Spearman correlation reveals that the lockdown $r = .400$, $P = .600$ ($\rho > .05$) and movement ban $r = .866$, $P = .333$ ($\rho > .05$). These measures were not effective reference to prevailing factors such as migration of population within cities and regions leading to transmission inherently.

Keywords: Coronavirus, disease, restriction, mobility, recovery, incidence.

Introduction

Coronavirus disease (COVID-19) has shaken the whole world and offered very little or no time to create safety measures. It has impacted the socio-economic status of mankind, even in the Middle East and Asia. (International Monetary Fund, 2019). Several service sectors, such as travel, tourism, education, and entertainment, which that play a supporting role in many economies, were disrupted due to movement restrictions imposed by governments. This pandemic has been a continual cause for global concern and the world is fighting to control its impact (Roubini, 2020).

In view of the severity of SARS-CoV-2 infections, infection fatality rate (IFR%) and case fatality rate (CFR%) are important measures to gauge the impacts of COVID-19 on population (Shen *et al.*, 2021; who.int, 2020). The infection rates are reported to be very high in China during the early stages of the COVID-19 outbreak, but are low in other Asian countries (Loannidis, 2021).

The virus spilled out from the city of Wuhan, China, in December 2019 has spread to more than 200 countries in nine months, paralyzing normal life (Worldometers, 2020). The disease is caused by anRNA virus that can spread easily through airborne media and contact with infected inanimate objects, thus, accelerating the transmission of the disease in populations (Maier *et al*., 2015; CDC, 2020).

The disease has spread rapidly across the world, resulting in 44 million infections with 1.1 million deaths at time of writing (WHO.int, 2020). In absence of a treatment measure, SARS-CoV-2 will continue to cause more infections globally. To stabilize the high incidence rates of the disease, preventive measures are very important to control the transmission and spread of infection at the grassroots level. Many organizations have

formulated awareness campaigns to urge the public to practice infection preventive measures at public areas and workplaces (WHO.int; CDC.gov; OSHA.gov). Guidelines are also laid out by governments of every country to counteract the transmission of SARS-CoV-2 locally.

To reduce the intensity of the pandemic and curb transmission of the virus, global health bodies and more than 50 governments have recommended social restrictions, movement prohibitions within and outside countries leading to lockdown either fully or partially (Atalan, 2020). A lockdown was first implemented in Wuhan, the epicentre of COVID-19, and other effected cities in Hubei province to quarantine the entire region from further transmission of the disease (Yuan *et al*., 2020). Following the Wuhan experience, many countries initiated lockdowns and the effects were greatly felt in developing and underdeveloped countries, where huge economic crises and unemployment developed (ILO, 2020).

Nevertheless, the drawbacks of lockdowns far outweigh the lives protected from infections despite the number of deaths recorded. Cuadradro *et al*. (2020) claims that limited restrictions on mobility through lockdowns can reduce the disease transmission in educational institutions. However, Nabi and Islam (2020) stated that lockdowns did not reduce infections, as observed in developing countries, like Bangladesh, Brazil, Chile, Pakistan and South Africa.

Andornico *et al*. (2020) said that the lockdown in French Guiana was successful in controlling the transmission of SARS-CoV-2, similar to Kharroubi and Saleh (2020) who found that a lockdown limited transmission of infections. Most of the research related to lockdowns and movement bans focused on economic loss, environment pollution, employment, healthcare and education. However, the effects of these measures on COVID-19 transmission and disease spread were not fully explored. This study attempts to understand the effectiveness of lockdowns and movement bans in Oman alongside other preventive measures. his study would also answer whether lockdown and movement ban can be an interim strategy to suppress disease transmission.

Materials and Methods

Study Area

This study was conducted using data reported from all the governates in Oman (Figure 1) and the data used for statistical analysis (covid19.moh.gov.om)

Data Collection

Daily cases and deaths were collected from January to October 2020 to analyze the impact of the lockdown and movement ban on COVID-19 incidence rates from data published by WHO (covid19.who.int; ourworldindata.org). The data from Oman was computed to obtain the cumulative cases and deaths. Data on active and recovered cases were also collected daily in the same period from www.worldometers.info and later computed to obtain the cumulative active and recovered cases for each month. To understand the calculation of fatality ratios, the following equation is followed.

Total confirmed cases = No. of confirmed deaths + No. of recovered cases + No. of active cases (virusncov.com)

Data on daily active cases and deaths computed from January to October 2020 were further analysed to calculate the IFR% CFR% and percent recovery rate.

IFR% and CFR% are calculated using the formulas referenced by WHO (www.who.int).

$$\text{IFR \%} = \frac{No.of\ deaths\ from\ disease}{No.of\ infected\ individuls} \text{ X } 100$$

$$\text{CFR \%} = \frac{No.of\ deaths\ from\ disease}{No.of\ \ confirmed\ cases\ of\ disease} \text{ X } 100$$

Statistical Analysis

Statistical analysis was performed using Spearman correlation analysis using SPSS software Ver. 26 bivariate two-tailed test to evaluate the significance of the lockdown

and movement ban measures on COVID-19 infection transmission and incidence rates. Correlation was performed with reference to null hypothesis and alternate hypothesis to conclude the results of the statistical analysis. A t-test for independent sample two-tailed analysis was also performed using XLSTAT statistical software for MS Excel to understand the significant difference that exists between the mean daily new confirmed cases and the mean new confirmed deaths during the lockdown and movement ban phases. The significance levels were tested at alpha $\alpha = .05$ at 95% CI.

Results and Discussion

The Sultanate of Oman is the second largest Arab country in the Gulf Corporation Council (GCC) with an area of 309,500 km^2, population of 5.15 million and population density of 12.90 persons per sq km. The country is divided into 11 governates, with 61 districts or Wilayat spread among them (NSCI, 2020) (Figure 1).

Lockdown and Movement Ban Regions

The government, under the orders of the supreme committee, had placed lockdown and movement ban in all governates to control the spread of COVID-19 between population and communities. With the increase number of confirmed cases and deaths over the region, lockdown or movement bans were implemented fully or partially. Many countries had earlier implemented lockdown, quarantines, or temporary restrictions to contain the spread of infection. China was the first country to enforce such measures in Hubei province on January 23rd.

Figure 1: Map of Oman showing the governates

[1] https://www.worldatlas.com/maps/oman

Descriptive Analysis of Lockdown and Movement Ban

Data analysis was done to assess the significance of lockdown and movement ban as effective measures to control the incidence rates. These two measures were critically evaluate for their role in containing the infection transmission and to enumerate the best mechanisms to follow for bringing down the infection rates in the country. The parameters studied to ascertain the effectiveness of lockdown and movement ban include, daily new confirmed cases, daily confirmed deaths, monthly cumulative active cases, monthly cumulative recovered cases from January to October 2020 during the lockdown and movement ban periods in Oman.

The government of Oman, unlike other countries within the region, implemented two full lockdowns until October to control rising COVID-19 cases. The first lockdown was from April 10th to April 22nd and later extended twice up to May 29th covering a total of 51 days. The second lockdown was from July 25th to August 8th spanning 15 days. The total lockdown duration, including the extension period, was 66 days (mean 16.5 ± 3.3) out of which the longest lockdown period was of 22 days. The gap between two successive lockdown and movement ban phases was 50 - 55 days where the first and second phases were enforced as continuous span (Figure 2).

In addition to the lockdown, the government had also introduced a movement ban as an alternative mechanism, during which all movement was prohibited in stipulated hours. Three movement bans were imposed till October covering 30 days (mean 10 ± 2.8) in total with the longest being 14 days. The first movement ban period was from July 25th, coinciding with the 2nd lockdown period and ended on August 2nd before the lockdown period. The second movement ban was from August 8th, coinciding with the end of the 2nd lockdown, and continued up to August 15th. The third movement ban was from October 11th to 24th. All the movement bans were imposed from 7 p.m. to 6 a.m. averaging for 8 - 11 hours (Table 1).

Confirmed Cases During Lockdown and Movement Ban

The daily case figures were examined monthly from January 2020 to October 2020 and were analyzed during the lockdown and movement ban periods. The first confirmed case in Oman was reported on February 24th. The daily cases increased from the first lockdown to the 2nd lockdown that ended on August 8th. The highest number of confirmed cases was reported during the 2nd lockdown, which lasted 15 days, and the lowest confirmed cases was reported in the 1st lockdown. The average confirmed cases during the lockdown period was 4252.7 ± 3101.3 contributing about 30.3% of the total confirmed cases noted from April to May, July and August (Figure 2). Daily new confirmed cases during the movement ban did not follow an increasing or decreasing pattern, while the 1st and 3rd movement ban period has high confirmed cases

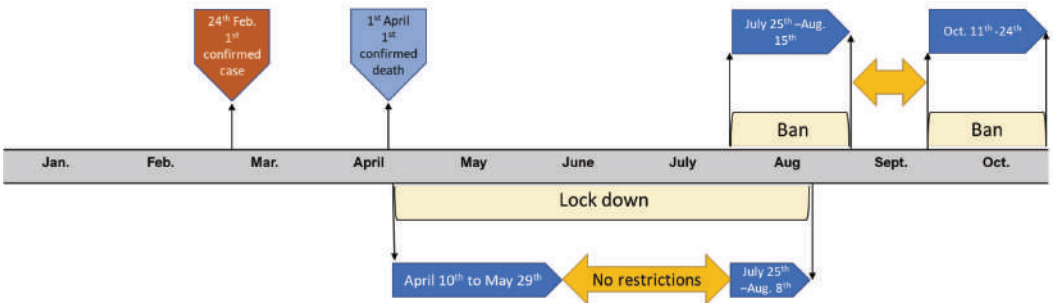

Figure 2: Timeline of lockdown and movement ban phases in Oman. Observations were recorded from January to October 2020 for the study parameters, however the first confirmed case was reported in February and confirmed death in April 2020. June and September 2020 had no lockdown or movement ban enforced

Table 1: Summary of new confirmed and death cases reported during lock down and movement ban phases

Variable Data	Lock Down				Movement Ban		
	1st	Extn. 1	Extn. 2	2nd	1st	2nd	3rd
	April 10th to April 22nd	April 22nd to May 8th	May 8th to May 29th	July 25th to Aug. 8th	July 25th to Aug. 2nd (7 p.m. to 6 a.m.)	Aug. 8th to Aug. 15th (9 p.m. to 5 a.m.)	Oct. 11th to Oct. 24th (8 p.m. to 5 a.m.)
No. of days	13	16	22	15	8	8	14
No. of confirmed cases	1089	1450	6051	8421	6513	2030	7708
No. of confirmed deaths	6	7	26	147	66	65	138
Average days	16.5				10		
Average confirmed cases/day	83.76	85.29	288.14	561.4	930.4	253.75	550.57
Average no. of confirmed cases	4252.75				5417		
Average no. of confirmed deaths	46.5				89.6		

compared to the 2nd phase. The highest cases were observed in the third spell movement ban which was for 14 days, the longest duration among all the phases. The average confirmed cases during all phases of the movement ban was 5417 ± 2444.1, contributing about 26.0% of the total confirmed cases noted in July, August and October 2020 (Figure 3).

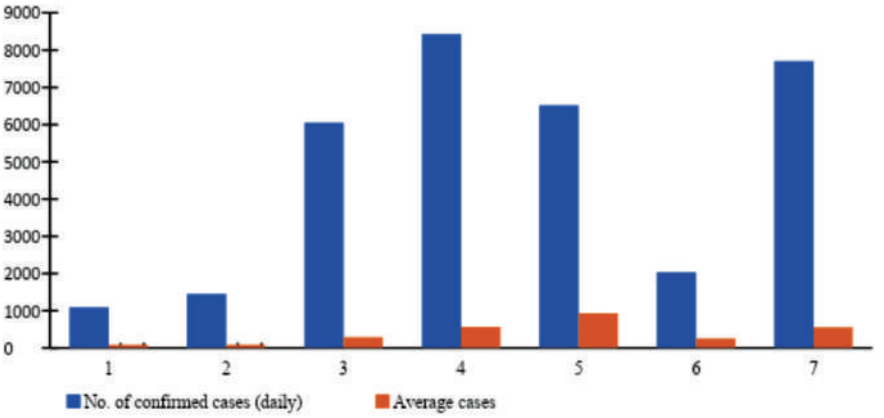

Figure 3: No. of confirmed cases with average values during both the phases. Blue bars represent the number of daily confirmed cases during recorded during lockdown and movement ban and the brown bars represent average number of confirmed cases during both the phases

[2] Data analysed from WHO.int 2020-Oman dashboard and reproduced. Lockdown dates are taken from national newspapers and supreme committee announcements

The mean number of confirmed cases per day during the lockdown phase was 254.6, and it was 578.2 per day during the movement bans. June and September 2020 are the months without a lockdown or movement ban, and the number of cases reported was lower by 33.3% than during the June to July 2020 lockdown span, and 19.4% lower than during the September to October 2020 movement ban span. The average confirmed cases from February to October ranged from 0.2 to 1293.5 per month with highest number of confirmed cases recorded in July and the highest new confirmed case reported in a single day was 2685 on October 5th (Figure 4).

Confirmed Deaths During Lockdown and Movement Ban

Cumulative daily new confirmed deaths from February to October 2020 were calculated for each month. The first confirmed death was reported on April 1st with 11 deaths logged that month. Total confirmed deaths during the lockdown phase was 186, with an average of 46.5 deaths in each phase, whereas the highest deaths during the 2nd lockdown coincided with the highest number of confirmed cases of COVID-19. otal confirmed deaths during the movement ban was 269, with an average of 89.6 deaths for each phase, and highest deaths recorded was in the 3rd phase that again coincided with the highest number of confirmed cases during that period.

The total confirmed deaths during lockdown and movement ban was 455, contributing 37.6% of confirmed deaths during April to October 2020. It is also interesting to note that the confirmed deaths were higher during the movement ban than the lockdown, and the highest confirmed deaths was observed in the 3rd lockdown and movement ban, which r lasted 15 and 14 days respectively (Table 1). However, regardless of the lockdown and movement ban, the total confirmed deaths up to October 2020 was 1208 with an average of (172.5 ± 106.1) deaths per month from April to October 2020, but there were no recorded deaths in February and March 2020. The confirmed deaths showed a gradual increase from April to October 2020 (Figure 5) and also during the lockdown and movement ban span (Figure 6). The number of recovered and active cases showed a gradual increase from

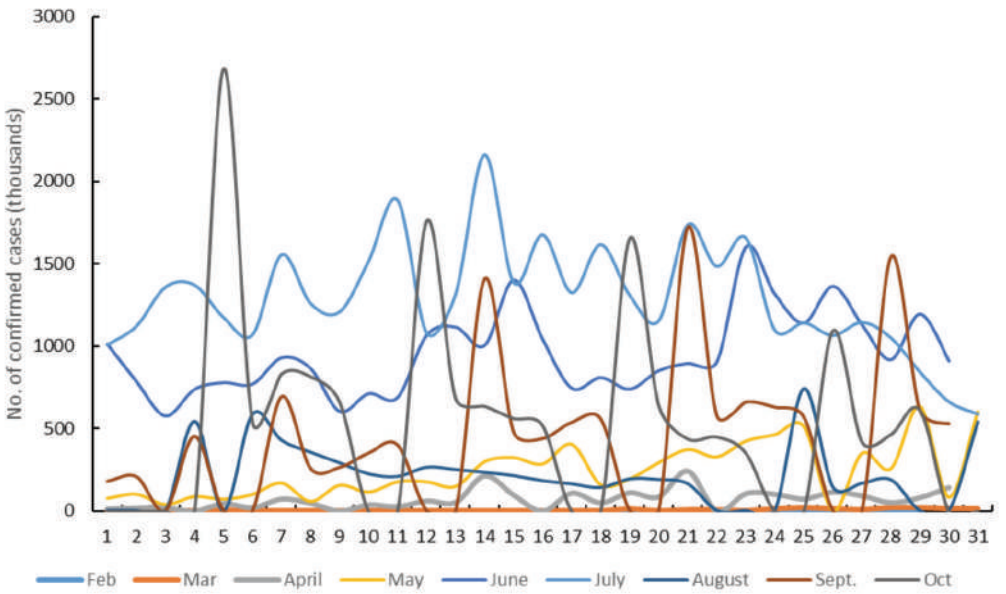

Figure 4: No. of cumulative confirmed cases day wise during the observation period. The lines represent the confirmed cases for each month from February to October 2020 reported day wise

February to July 2020 but decreased in August 2020 and showed a slight rise in September and October 2020 (Figure 7). The average confirmed deaths from April to October ranged from 0.36 to 8.8 per month, with the highest number of deaths reported in a day was 62 on August 4th (Figure 8).

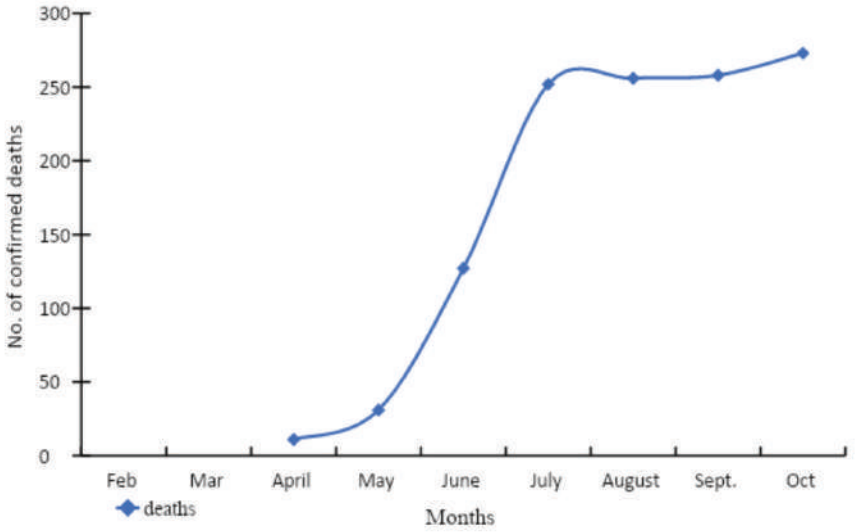

Figure 5: Growth curve of no. of confirmed deaths. The line shows the number of confirmed deaths reported from each month from February to October 2020. The line indicates steep rise in the confirmed deaths from April 2020 and reached peak during the first week of July and then showed gradual increase from August to October 2020

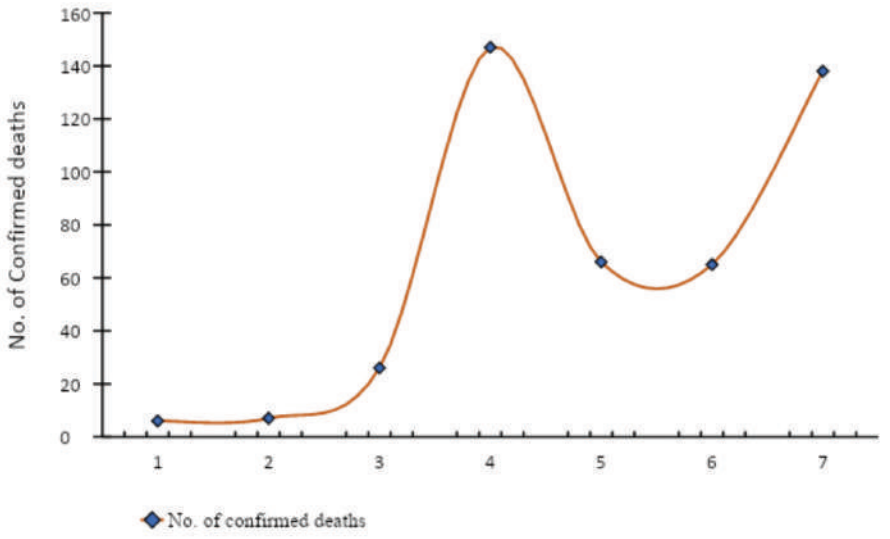

Figure 6: Growth curve of no. of confirmed deaths in both the phases. The line graph shows increase in number of confirmed deaths in lockdown and movement ban phases. The confirmed deaths rate increased from the first extension spell of lockdown phase until the second spell and then the rates decreased during the first spell of movement but rise again in the third spell which is during October 2020

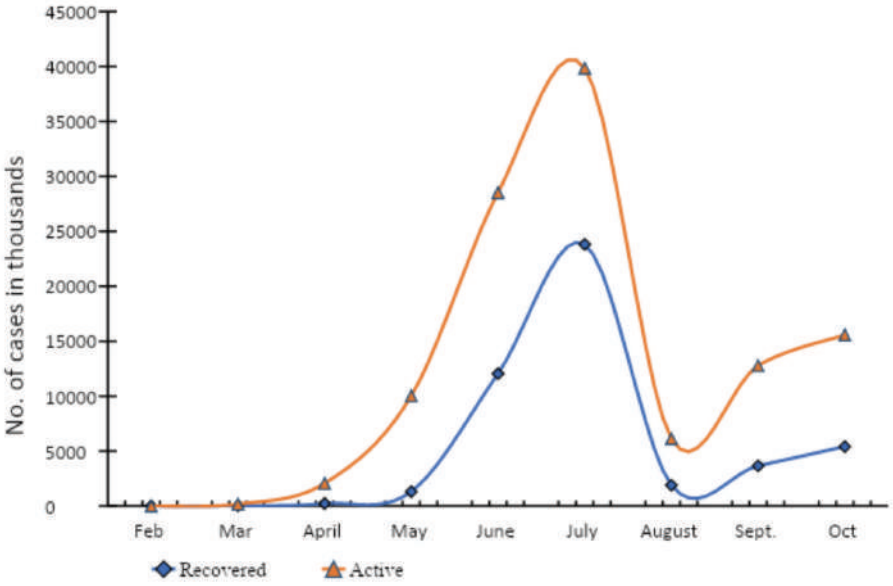

Figure 7: Trend line showing recovered and active cases reported. The reddish-brown line shows the active cases and the blue line indicates the disease recovery rate. In general, there would be more active cases than recovered cases. The active cases were first reported in February 2020 and peaked in July 2020 and recovered cases also peaked in July 2020. Active cases and recovered cases lines show parallel pattern all through the study period, indicating a reciprocating trend

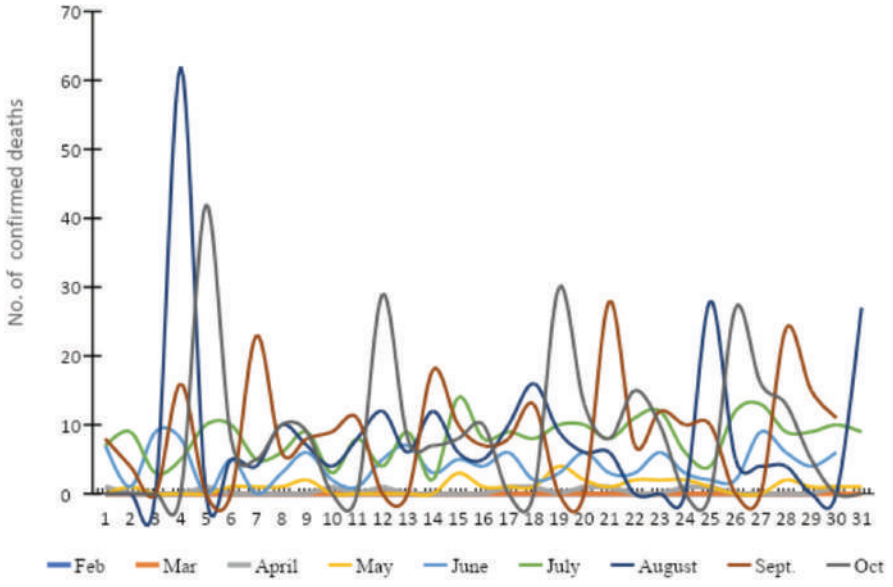

Figure 8: No. of cumulative confirmed deaths reported day wise. The lines show total confirmed deaths for each month from February to October 2020 day wise

The infection to fatality ratio (IFR %) showed an average of 1.8% from February to October 2020, with a peak of 6.0% in August 2020 because the highest number of deaths reported per day were in that month, and the least of 0.35% was seen in May 2020. The case fatality ratio (CFR%) showed an average of 1.06% from February to October, with a peak of 4.0% in August (Figure 9). The computed recovery rate from the total number of confirmed cases was 89.9% at the end of October 2020.

Statistical Description During Lockdown and Movement Ban

To evaluate the significance of the two preventive measures, the hypothesis was set to validate from the outcomes of the analysis.

H_0: $\rho = 0$: Null hypothesis – no significant correlation or relationship between the variables (x variable = Length of lockdown/ movement ban) and (y variable = No. of confirmed cases).

H_1: $\rho \neq 0$: Alternate hypothesis – significant correlation or relationship between the two variables (x variable = Length of lockdown/ movement ban) and (y variable = No. of confirmed cases).

Statistical analysis considering different variables during the lockdown and movement ban phases were performed to assess the significance of each measure in controlling infection transmission and moderating the pandemic in the region. Spearman correlation analysis showed moderate positive association between the number of lockdown days (M = 16.5 ± 3.87) and the number of confirmed cases reported daily (M = 4252.7 ± 3581.0) during the observation periods but the relationship between the two variables was not statistically significant in the population $r = .400$, $P = .600$ ($\rho > .05$, $n = 4$), which implied that the new confirmed cases observed during the lockdown phase were not the result of the two measures.

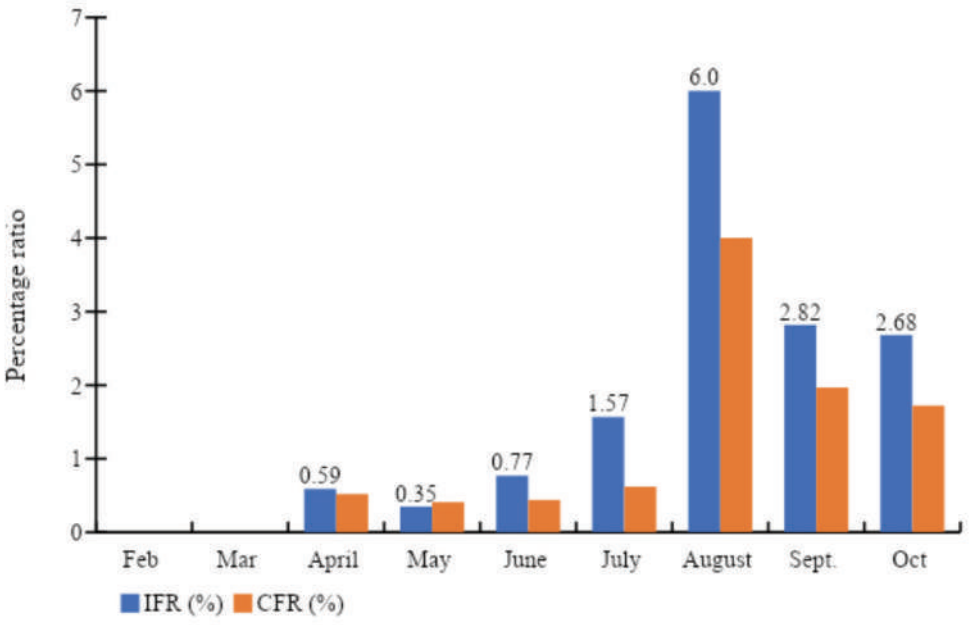

Figure 9: Comparative fatality ratios from infected and confirmed cases. The blue bars show infection fatality ratio and the reddish-brown bars represent case fatality ratio from February to October 2020. The IFR % and CFR % during February and March 2020 are nil and show high percent in August 2020

The statistical analysis revealed strong positive association between number of days of movement ban (M = 10 ± 3.46) and the number of daily new confirmed cases (M = 5417.0 ± 2993.4) during the observation period, thereby indicating there was no significant relationship between the number of days of movement ban to the number of new daily confirmed cases r = .866, P = .333 (ρ > .05). Again, it can be stated that the new confirmed cases observed during the movement ban phases did not necessarily result rom the measure.

An independent sample t-test was conducted to compare the statistical difference between the mean number of confirmed cases during the lockdown and movement ban phases. The analysis found significant difference between the mean number of confirmed cases reported during the lockdown (261.7 ± 289.7) period and movement ban (1761.0 ± 470.2); $t(94) = 1.986$, $p = .001$ ($\rho < .05$) indicating that the duration of lockdown and movement ban has no effect on the rising number of daily confirmed cases

Spearman correlation analysis to test the association between the number of confirmed deaths (2.84 ± 8.09) and confirmed cases (261.7 ± 289.7) during the lockdown revealed moderate positive correlation between them r = .725, p = .000 (ρ < .05) and the link between number of confirmed deaths reported and the number of confirmed cases during the lockdown was statistically significant (Figure 10).

Additionally, the correlation analysis between the number of confirmed deaths (9.44 ± 11.35) andnumber of confirmed cases (494.5 ± 452.4) during the movement ban phase also showed moderate positive correlation r = .694, p = .0001 (ρ < .05), which revealed a significant relationship, indicating that an increase in new daily confirmed cases would cause more deaths from COVID-19 (Figure 11).

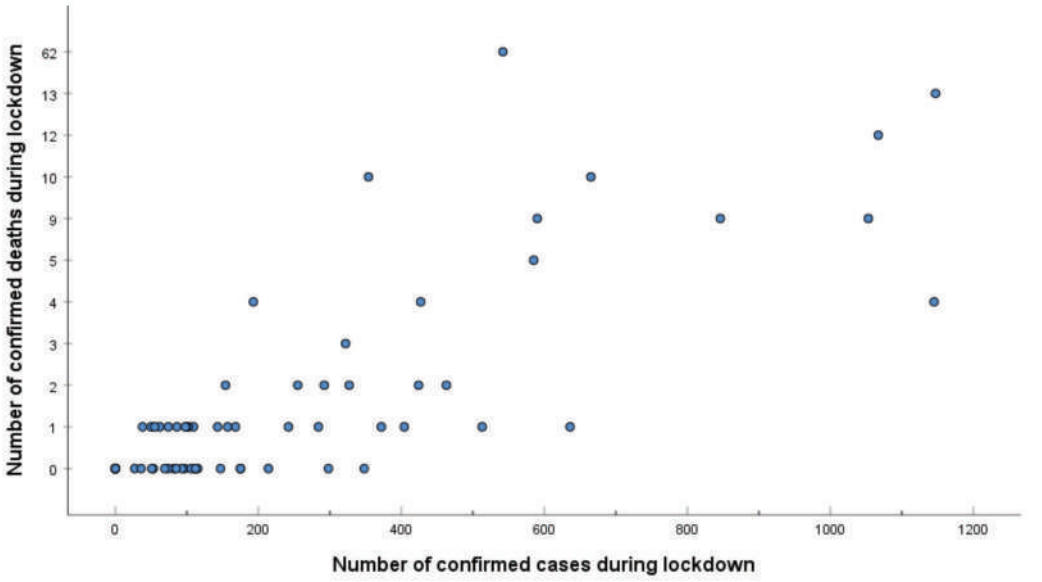

Figure 10: Scatterplot of relationship between confirmed cases and confirmed deaths in lockdown. The scatter dots represent the number of deaths to the number of cases reported. Both variables show close association in the study. Increase cases during lockdown resulted in proportionate increase in number of deaths

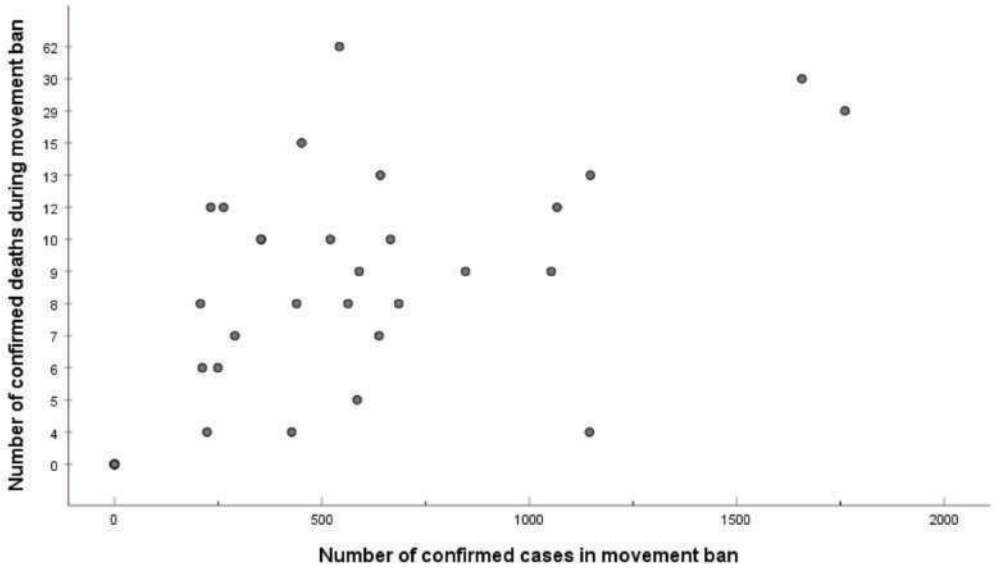

Figure 11: Scatterplot of relationship between confirmed cases to confirmed deaths during movement ban. The scatter dots represent the distribution of confirmed cases to the number of deaths during movement ban phase. The two variables show association, indicating an increase in the number of deaths was the result of anincrease in number of cases

Discussion

The effect of COVID-19 was felt in varying intensities across different countries around the world. Some countries experienced a severe impact from the pandemic due to the high number of cases and deaths, but others had fewer cases and deaths. Regardless of the severity of the outbreak in a country, the SARS-CoV-2 was thriving in the environment causing widespread transmission and infections. This study was limited to evaluating the impact of lockdown and movement on the raising COVID-19 cases in Oman, in addition to other preventive measures in place. At this juncture, he rising incidence rates and deaths, and efforts taken to control transmission are a serious concern. Unless proper mitigation and interim measures are taken, and until an effective treatment is released, the pandemic would continue to cause more infections. In response to such situation, most countries have adopted full or partial lockdowns to moderate the virus transmission.

Currently, almost every country has gone through either a full or partial lockdown at least once. Some countries have implemented curfews to restrict mass movement of people to avoid transmission of infections (Andronico *et al*., 2020). Unlike other countries, where lockdown and mobility restrictions proved effective in reducing the infection rates (Cuadrado *et al*., 2020), Oman's measures showed no decrease in the number of cases and deaths in all the governates. The highest cases were observed in Muscat governate. Within the capital region most cases were reported in densely populated communities (Khamis *et al*., 2020).

On the contrary, COVID-19 cases during the entire lock down and movement ban phases showed a gradual increase, despite the restrictions on human mobility. This suggests that such measures were not effective in controlling the transmission because a large population confined indoor or in a closed environment with poor ventilation is likely to be susceptible to infections. Closed environments are also favourable for the virus to transmit

through fomites. In these conditions, a small amount of virus can be sufficient to cause transmission through infected objects (Boone & Gerba, 2007; Sattar *et al*., 1987).

The movement ban was enforced only from 7 p.m. to 6 a.m. in all the three phases. Such short spells of restrictions failed to moderate the infection rates of the disease and did not prove effective in controlling viral infections from the way SARS-CoV-2 spreads through airborne media (Li *et al*., 2020). Though movement ban were strictly enforced, some small-scale gatherings in enclosed environments were reported in some interior communities, where there was a potential rise in infections from neighbouring areas. When the restrictions on movement were relaxed during the day, it was likely that transmission and infections spread (Chen *et al*., 2020). The lockdown was implemented to control the sudden rise in infections that was observed in April, which was three times higher than the preceding month. But the lockdown and movement ban were not effective in suppressing infections, t and active cases continued to rise, even though restrictions in some countries proved effective (Kharroubi & Saleh, 2020).

However, the number of recovered cases improved during the lockdown and movement ban phases, contradicting the rising IFR % and CFR %. Furthermore he number of confirmed deaths and active cases continued to rise during the lockdown and movement ban phases, which implies these measures had little effect in moderating the infection and fatality rates from COVID-19, though more than 85% of the infected cases recovered during both phases. Therefore, the analysis proved the hypothesis statements that the two preventive measures had no significant relationship with the increasing disease rates from COVID-19. Another challenge which would have been difficult to control was the economic and revenue loss through rising COVID-19 cases. The inconsistent execution of the movement ban and lockdown in the different governates played a role in their failure to bring down infection rates. Moreover, the effectiveness of these measures were not evaluated on a small scale before enforcing them nationwide. To contain the pandemic in Oman, cross-border movement between other GCC countries should be restricted t. It is also recommended that the effectiveness of such preventive measures be studied on a small scale before launching them at the national level. Further research, should focus on the effect of both measures at a micro level, such as city or district level, to observe the migration rate index of population before and during lockdown and movement ban phases.

Conclusion

This study aims to understand the significance of lockdown and movement ban measures that were taken in Oman to control infection rates of COVID-19. The study was limited by the unavailability of case and death figures in each governorate. This date would have provided more critical analysis to compare the significance of the lockdown and movement ban in each governorate.

The outcomes of the study contributes to the literature of COVID-19. Observations on daily new confirmed cases and daily confirmed deaths were gathered from January to October 2020 to study the trend of COVID-19 incidence rates during the lockdown and movement ban phases. To reduce the chances of further deaths in the country, the first lockdown was enforced in April 2020 and extended up till the end of May 2020. Though both the measures were implemented across the country in all governorates,

The statistical analysis proves that the two variables demonstrate no association and the relationship between the lock down and movement ban measures is not significant.

The following critical findings are drawn.

- The movement ban that was implemented as an alternative approach to counteract the COVID-19 was not very effective in controlling transmission due to partial and discontinuous execution.

- Movement ban are only temporary restrictions on human mobility during certain hours of the day, and such restricted movements did not completely impair people from having social gatherings or community activities in indoor or enclosed environments.
- Relaxation on human mobility after the movement ban during the daytime will possibly lead to resurgence of infection and incidence rates unless other preventative measures are strictly followed by all people.
- There is no significant relationship to show that lockdown or movement ban measures had moderated cases, implying that the raising infection rates show an increase trend from April to October regardless of these measures in place.
- During the movement ban and lockdown phases, the migration of people between cities and within regions were not monitored. This was a missed opportunity to calculate the migration index to which would lead to finding out the possible percentage of infections occurring from neighboring areas and appropriate mitigation measures can be enforced.
- Though these measures proved effective in reducing the incidence rates in other countries, the efficiency of these measures depends on local factors, such as effective administrative and technical planning.

Future scope

Further research can be carried out to investigate the impact these measures on each city and governorate in the country The effectiveness of these measures should be studied by considering migration between cities and governorates to evaluate the migration index and to determine any effect on controlling disease incidence rates.

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