

# The Effect of Strict State Measures on the Epidemiologic Curve of Covid-19 Infection in the Context of a Developing Country: A Simulation From Jordan

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## Research Article

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2 **the Context of a Developing Country: A Simulation from Jordan**

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26

1 **Abstract**

2 **Background:** COVID-19 has posed an unprecedented global public health threat and caused a  
3 significant number of severe cases that necessitated long hospitalization and overwhelmed the  
4 health services in most affected countries. In response, the governments initiated a series of non-  
5 pharmaceutical interventions (NPIs) that led to severe economic and social impacts. The effect of  
6 these intervention measures on the spread of the COVID-19 pandemic are not well investigated  
7 within developing countries settings. This study simulated the trajectories of COVID-19  
8 epidemic curve Jordan and assessed the effect of Jordan's strict NPI measures on the spread of  
9 COVID-19.

10

11 **Methods:** A modified Susceptible, Exposed, Infected, and Recovered (SEIR) epidemic model  
12 was utilized. The compartments in the proposed model categorized Jordan population into six  
13 deterministic compartments; Suspected, Exposed, Infectious Pre-symptomatic, Infectious with  
14 Mild Symptoms, Infectious with Moderate to Severe Symptoms, and Recovered. GLEAMviz  
15 client simulator was used to run the simulation model. Epidemic curves were plotted for  
16 estimated COVID-19 cases in the simulation model, and compared against the reported cases.

17

18 **Results:** The simulation model estimated the highest number of total daily new COVID-19  
19 cases, in the pre-symptomatic compartmental state, to be 65 cases, with an epidemic curve  
20 growing to its peak in 49 days and terminating in a duration of 83 days, and a total number of  
21 simulated cumulative case count of 1,048 cases. The curve representing the number of actual  
22 reported cases in Jordan showed a good pattern compatibility to that in the mild and moderate to  
23 severe compartmental states. Reproduction number under the NPIs was reduced from 5.6 to less  
24 than one.

1

2 **Conclusion:** NPIs in Jordan were effective in controlling the COVID-19 epidemic and reducing  
3 the reproduction rate. Early strict intervention measures showed evidence of containing and  
4 suppressing the disease.

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7 **Keywords:** COVID-19, Simulation, SEIR, SARS-CoV, Jordan, SIR

1 **Inrtoduction**

2 Newly evolved Coronaviruses (CoVs), such as the severe acute respiratory syndrome  
3 coronavirus (SARS-CoV) and the Middle East respiratory syndrome coronavirus (MERS-CoV),  
4 have posed global public health threats, including the 2003 outbreak in Guangdong, China, and  
5 the 2012 outbreak in the Middle East, respectively (1, 2). Similarly, SARS-CoV-2, an enveloped  
6 positive-sense RNA virus that infects humans (1), was initially reported as a localized  
7 pneumonia epidemic around December 2019, in China, before being declared as a pandemic by  
8 the World Health Organization (WHO) early 2020 (3, 4). COVID-19, the disease caused by  
9 SARS-CoV-2, is today a global epidemic and of high priority. As of June 21, 2020, more than  
10 8.5 million confirmed COVID-19 cases, and about 500 thousand deaths, have been recorded  
11 worldwide (5).

12 While COVID-19 can cause severe illness and death, many uncertainties exist. The full extent of  
13 the pandemic, especially in developing countries, the full clinical spectrum of illness, including  
14 the prevalence of mildly symptomatic cases (4), and the true case fatality rates (6), are not truly  
15 known. With 81% of infected cases developing only mild symptoms of COVID-19, it was  
16 suggested that many infected individuals with mild symptoms may not seek testing (7). This  
17 adds to the uncertainty of COVID-19 (8), especially in the developing countries with limited  
18 testing and treating capabilities, and may make the true case count be as much as 10 times higher  
19 than reported (9). Projecting case count, therefore, is an essential tool for public health response  
20 measures and health system management.

21 Globally, two vital non-pharmaceutical interventions (NPIs) strategies have been identified to  
22 control the spread of an epidemic; mitigation and suppression. The former focuses on slowing the  
23 spread of the disease, but not necessarily stopping it, by reducing the healthcare demand peak and

1 by protecting at risk groups. Suppression, on the other hand, focuses on reversing the epidemic  
2 growth, reducing case numbers to low levels and maintaining that situation indefinitely (10, 11)  
3 In developed countries these measures have been effective in controlling the spread of COVID-19  
4 (10, 12, 13). Such effect has been assessed using mathematical modeling that simulated the spread  
5 of SARS-CoV-2 infection across the population and shaped control measures that might mitigate  
6 future transmission (10, 12-21). One outcome of such simulation is the predicted epidemic curve  
7 representing the number of infections caused by the virus over time. Using a set of parameters,  
8 such simulation measures the impact of different interventions that can directly affect the predicted  
9 epidemic curve (21). Mathematical modelling, therefore, presented itself as a powerful tool for  
10 understanding transmission of COVID-19 and exploring different scenarios. Still, using such  
11 modeling from developing countries, where healthcare systems are relatively weak, protective  
12 equipment are scarce, and poor testing and treatment capacity exist, is controversial (7, 22, 23).  
13 The Hashemite Kingdom of Jordan, a country in the Middle East region, initiated, on February  
14 27, its national response to COVID-19 by banning non-Jordanian travelers from high-risk  
15 countries from entering Jordan. On March 2, the first COVID-19 case was reported for a national  
16 arriving from Italy. In the same week, Jordan initiated a quarantine for arrivals from selected  
17 European countries. On March 15, a total of 12 new cases were reported, and all educational  
18 institutions, tourism sites, cafes, and restaurants were ordered closed. All arriving passengers  
19 (N=5,050) were then handled as suspected cases and immediately quarantined. Jordan then  
20 prohibited travel between governorates, suspended all flights, closed borders, suspended public  
21 transportation, closed commercial complexes, suspended non-emergency medical services,  
22 closed public and private sectors, implemented stay-at-home policy, and prohibited public,  
23 social, and religious events. Jordan then declared national lockdown, a state of emergency, and

1 imposed a curfew. During the early couple of days of the curfew, a complete nationwide  
2 lockdown banned people from leaving their homes. Citizens were then allowed five specific days  
3 to locally move, walk, and neighborhood grocery stores were allowed to open between 10 AM  
4 and 6 PM. Driving was not allowed and moving between administrative geographic boundaries  
5 was permitted under emergency circumstances.

6 The number of newly reported COVID-19 cases in Jordan fluctuated between three cases and 42  
7 daily cases (mean number of daily reported cases was 15 cases). As of May 1, the number of  
8 reported cases was **459** case including 8 deaths. Cases seem to have clustered among persons  
9 within the same family and limited number of cases have been identified to be of unknown  
10 origin. Testing, taking place during the time of preparing this manuscript, has been conducted  
11 randomly within each of the 12 Jordanian governorates and limited number of cases have been  
12 identified using this approach. Early May, the number of local cases reached zero for about 10  
13 days.

14 At this stage, it becomes necessary to simulate the COVID-19 epidemic curve in Jordan,  
15 especially for those with mild symptoms, as this will give an indication of the actual national  
16 situation. Without proper simulation of cases by clinical manifestation, decisions to re-open  
17 businesses will be arbitrary and not data driven. Towards this, the current research attempted to  
18 mathematically simulate the ongoing trajectory of COVID-19 outbreak in Jordan and to model  
19 the effect of national interventions utilizing real-time scenarios. The simulation of the COVID-  
20 19 outbreak could be of added value for public health response planning and future expectations.  
21 The current research will also advance our knowledge about COVID-19 in developing countries  
22 and the effect of publicized responses implemented with widespread adherence and support in  
23 Jordan.

1 **Methods**

2 A modified Susceptible, Exposed, Infected, and Recovered (SEIR) epidemic model (24) to  
3 simulate the spread of COVID-19 in Jordan was utilized. SEIR model simulates the infectious  
4 disease spread assuming no births, deaths or introduction of new individuals occurred. As such,  
5 each individual is initially assigned to each of the following disease states (deterministic  
6 compartments): susceptible (S), exposed (E), infectious (I) or recovered (R). The deterministic  
7 compartments in the SEIR model are fairly sophisticated quantitative mathematical models yet are  
8 easily run utilizing public data and known disease characteristics (24). We have modified the  
9 standard SEIR model by adding compartmental states that reflect the compartmental population  
10 and research needs. Our modified model categorized Jordan population into six deterministic  
11 compartments; susceptible, exposed, infectious pre-symptomatic (representing the total number of  
12 infections in Jordan), infectious with mild symptoms (i.e. not needing hospitalization), infectious  
13 with moderate to severe symptoms (i.e. needing hospitalization), and recovered.

14 In designing the modified simulation model, we assumed that an exposed individual may become  
15 infectious pre-symptomatic who then may progress to recovered, or progress to either mild or  
16 moderate to severe symptomatic individual, both of whom may then progress to recovered. The  
17 following brief shows the compartmental states applied in our study:

- 18     ▪ **Susceptible:** All non-immune population in our study (all Jordan population).
- 19     ▪ **Pre-symptomatic:** Population producing or showing no COVID-19 symptoms yet, albeit  
20       are infectious (11).
- 21     ▪ **Symptomatic (Mild or Moderate to Severe):** population showing COVID-19  
22       symptoms.
- 23     ▪ **Recovered:** population recovered from COVID-19 infection.

1 The modified model predicts the number of simulated COVID-19 cases by each compartmental  
2 state in Jordan. It also has the potential to distinguish hidden (asymptomatic or mild, not seeking  
3 hospital care) from identified infected cases needing hospitalization (moderate to severe cases).  
4 Indeed, standard SEIR models are estimated assuming that all infected people are reported. Such  
5 an assumption for the novel COVID-19 pandemic is largely unreasonable, as many infected  
6 people show no or mild symptoms and as the testing procedure is not available in mass, many  
7 remain undetected (25). The model also accounts for hospitalization of moderate to severe cases  
8 by adjusting the contact rate. It is assumed that such cases will be detected and quarantined  
9 within healthcare setting as they will be seeking medical services. Hence, their contact rates will  
10 decrease tremendously.

11

## 12 **Simulated Model and Modelling Software**

13 We have utilized the GLEAMviz client simulator (26) that combines world data such as country  
14 population and human mobility. The GLEAMviz elaborates compartmental stochastic models  
15 (27) for disease transmission in global epidemic event. Our analysis assumes the first case  
16 entered Jordan on February 1, and the initial simulation started as such. Population size of 10.2  
17 million was built-in the client simulator. As well, the model allows for limitation of mobility  
18 within the population and restriction of travel as built-in functions within the designed models.  
19 The simulator provides rates within each compartment which were converted into numbers based  
20 on Jordan population size.

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## 1 **Model Parameterization**

2 To run the simulation model, we utilized a series of parameters as indicated by the simulator

3 (Table 1) (26). They are:

- 4       ▪ Beta ( $\beta$ ): is the contact rate which describes the spread of disease in the community.  
5       Since Jordan culture is homogeneous, and people follow traditional forms for  
6       greeting, we have set the standard contact rate ( $\beta$ ) to 0.37 (16, 28, 29). To reflect the  
7       status of measures in Jordan, we added an extra layer (exception) to designate the  
8       NPIs that took place on March 17. As such, the contact rate value ( $\beta$ ) was reduced  
9       from 0.37 to 0.06 (30) between March 17 and April 24. The contact rate value ( $\beta$ ) was  
10      set to 0.2 between April 24 and May 15 reflecting partial lifting of the curfew and  
11      partial reopening of selected businesses. After that, the contact rate value ( $\beta$ ) was set  
12      to its original value of 0.37.
- 13      ▪ Epsilon ( $\epsilon$ ): incubation period from getting infected to become infectious. It is set to  
14      5.2 days (9, 10, 31).
- 15      ▪  $P_s$ : Probability of developing severe COVID-19 symptoms. This value was set at 0.01  
16      (32).
- 17      ▪ Recovery rate (mu or  $\mu$ ) which indicates the time until the infectious case becomes  
18      recovered. Previous research (33) reports the recovery time for COVID-19 is 14 days  
19      ( $\mu = 1/14$  days). Hence, we have used this value as the recovery rate ( $\mu = 0.07$ ) in our  
20      model.
- 21      ▪ Alpha ( $\alpha$ ): denotes the transmission rate of hospitalized (moderate to severe) cases.  
22      We have used the value of  $\alpha = 0.001$  to reflect the negligible transmission rate of  
23      hospitalized patients.

- 1       ▪  $R_0$ : the reproduction number for COVID-19. Based on the above values,  $R_0$  was  
2       calculated as 5.6 (see supplementary 1 for formula). The basic reproduction number  
3       ( $R_0$ ) measures the transmission (contagious) potential of COVID-19 and describes the  
4       average number of secondary infections caused by a typical primary infection in a  
5       completely susceptible population.  $R_0$  of 5.6 value was reported in other similar  
6       global simulations (34). Literature reported  $R_0$  range between 2.3 and 6.5 (28, 35-37)  
7       and re-analysis of Chinese data provided an updated estimate of 5.7 (95% CI 3.8-8.9)  
8       (37).

9

10   Our model does not provide estimates for the proportion requiring intensive care units (ICU)  
11   within hospitals nor the estimated number of COVID-19-related deaths. Providing these  
12   estimates requires details of the clinical fraction of infected, the likelihood of clinical cases being  
13   severely ill, as well as a detailed understanding of the capacity of the health services in Jordan.  
14   Two basic models were run to simulate the estimated numbers of COVID-19 cases by clinical  
15   manifestation assuming two separate scenarios; NPIs scenario (S1), as in that implemented in  
16   Jordan, and no-action scenario (S2). The former considered NPIs implementation dates (starting  
17   March 17 and ending May 15), while the latter assumed no NPIs took place (see Additional File  
18   1). For each compartmental state, the number of simulated daily new COVID-19 cases was  
19   plotted. Accordingly, the epidemic curves are presented along with the duration of the epidemic  
20   (in days) and the time to the peak (in days). Each S1 curve was also fitted against the reported  
21   daily number of cases.

1 **Results**

2 Figure 1 presents the number of daily new COVID-19 cases in the pre-symptomatic  
3 compartmental state, simulated under the S1 and S2 using the same scale. S1 curve is  
4 demonstrated as a “baby” curve under S2 curve that started after February 1 and ended before  
5 April 20. The simulation model, under S1, predicted that on March 20 the highest number of  
6 daily new cases in the pre-symptomatic compartmental state will be 65 cases, after which, the  
7 number of simulated daily new cases started to decrease. By April 24, the predicted daily new  
8 cases leveled at zero. Considering that the simulation was set to start on February 1, and the NPIs  
9 commenced on March 17, it took the epidemic curve 49 days to grow to its peak and the total  
10 duration of the epidemic curve was predicted at 83 days. The cumulative number of cases was  
11 predicted at 1,048. For the hypothetical scenario of no-action (S2), the epidemic took a total of  
12 147 days to reach its peak of 238,142 daily new cases by June 27, and the cumulative number of  
13 cases reached about 9.5 million around December 1.

14 The simulated daily new mild COVID-19 cases under S1 reached its peak on March 21 with 36  
15 cases and a total duration of 49 days (Figure 2). After which, the simulated daily new mild case  
16 count started to decrease and reached, on April 27, zero daily new cases (total duration of the  
17 epidemic curve was 87 days).

18 As seen in Figure 3, the simulated daily new moderate to severe cases, under S1, reached a  
19 maximum number on March 24 with a total of 46 cases (a total of 53 days). The number then  
20 decreased to zero cases on April 27 (total number of days for the epidemic was 87 days).

21 In Figure 4, we plotted the actual reported daily new cases in Jordan against the simulated cases  
22 in our model (S1). The curves representing the simulated number of daily new COVID-19 cases,  
23 in both the mild and moderate to severe compartmental states, had good pattern compatibility

1 with those depicting the number of reported cases in Jordan, with a peak of new cases on March  
2 24.

3 Under S1, the simulated cumulative recovery was 1,044 cases by June 30. Out of the total  
4 cumulative cases, 695 cases were in the moderate to severe compartmental state, i.e. needing  
5 hospital care, while 795 were in the mild compartmental state, i.e. mostly hidden cases within the  
6 community. As well, based on the S1 model, the simulated reproduction number ( $R_0$ ) for  
7 COVID-19 after implementing NPIs in Jordan was estimated at 0.9.

8 Further comparisons between the S1 and S2 simulated models are presented in the  
9 supplementary figure (see Additional File 2).

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## 1 **Discussion**

2 With COVID-19 imposing a global public health and socioeconomic uncertainties, governments  
3 are counting on its people to adapt to NPIs in an effort to reduce the impact of the epidemic.  
4 Combined effort of both the government and the people are then necessary to bring the epidemic  
5 under control. How people react and respond to the implemented NPI measures are critical to the  
6 epidemiological presentation of the epidemic. In this context, the current study assessed the  
7 effect of NPIs implemented in Jordan on the COVID-19 outbreak utilizing simulation  
8 techniques. The simulated epidemic curves for COVID-19 provided evidence that Jordan has  
9 successfully implemented NPI measures that facilitated suppressing (containing) the spread of  
10 the epidemic by reducing the number of daily new reported cases and the total duration of the  
11 epidemic. The effects of the adopted NPIs in Jordan on the number of daily new cases and the  
12 duration of the epidemic are even more appreciated when compared to the catastrophic effects of  
13 the hypothetical scenario of no-action (see Additional File 2). Our results suggest that swift,  
14 intensive, and targeted lockdowns in Jordan have led new COVID-19 cases to plummet and  
15 health system be protected. Our research, therefore, suggests that a strong containment policy  
16 implemented early on can combat the spread of the COVID-19 epidemic.

17 The simulated model suggests that Jordan has presented a unique strategy that allowed  
18 “snuffing” the COVID-19 pandemic at an early stage and, supposedly, resuming normal life  
19 seemingly more quickly than many others. However, herd immunity has not been secured and a  
20 second wave remains a concern. This is especially evident given that after about 10 days of zero  
21 new cases in late April and early May, a new cluster of cases emerged and a new epidemic curve  
22 started. These cases were traced to a truck driver who tested negative at the border in late April,

1 and then was admitted to the hospital as a COVID-19 case on May 8. So far, the second wave  
2 has produced a daily case count of about 15 cases between May 8 and June 20.

3 Strict NPI measures implemented in Jordan, which lasted for more than six weeks, reduced  
4 COVID-19 transmission and likely reduced the reproduction number to less than one. A similar  
5 discussion was presented for the UK, for example (13), where, in the absence of control  
6 measures, the epidemic would quickly overwhelm the healthcare system. A combination of  
7 moderate interventions (school closures, shielding of older groups and self-isolation) was  
8 predicted to be unlikely to prevent the epidemic that would far exceed available ICU capacity in  
9 the UK. More intensive lockdown-type measures, however, predicted an effective protection of  
10 the healthcare system from being overwhelmed. Of importance, lockdown scenario for the UK  
11 effectively reduced  $R_0$  near or below one (13).

12 Our results are critical not only for public health decision makers, but also for risk  
13 communication and lessons learned. In case the new wave of the epidemic hits, the notion to  
14 initiate strict measures are already established and the model outcomes are supportive public  
15 messages to enhance proper implementation of strict measures. This data-driven approach is  
16 critical to ensure population commitment and set examples for other countries with similar  
17 resources and culture.

18 The simulation presented in the current study has limitations. It was designed to monitor the  
19 evolution of the COVID-19 epidemic spread in Jordan utilizing parameters presented about the  
20 disease from experience within developed countries. However, at this stage of the epidemic,  
21 country specific parameters are not available. Further, the contact rates used in the current  
22 simulation were generalized for the whole population and did not consider variability within  
23 households or local communities. The assumption of a universal contact rate used in the

1 proposed model was, however, adjusted for all cases with moderate to severe clinical  
2 manifestations. Considering that these cases are most likely to be detected within healthcare  
3 settings and be hospitalized, we reduced their contact rate to its minimum to overcome this  
4 limitation.

5 A combination of NPIs with isolation and contact tracing were reported to present a synergistic  
6 effect that increased the prospect of containment of COVID-19 (38). Knowing that Jordan has  
7 implemented strict contact tracing and isolation of contacts limits our ability to clearly compare  
8 the actual reported numbers to those presented under S1. Until detailed information about cases  
9 identified via contact tracing and isolation are made available, the presented model (S1) is the  
10 only available method to meet the objective of the current study. As well, the numbers presented  
11 under S2 seemed to be high values as it assumed no prevention and control measures were  
12 implemented. Their interpretation, therefore, should be limited to comparison with S1 and should  
13 be seen as mostly hypothetical.

14 Until today, COVID-19 models presented from developing countries are scarce and not fully  
15 investigated especially where disease suppression is considered as the main strategy to combat  
16 the epidemic and reduce the potential impact of cases on the healthcare systems.

17

## 18 **Conclusions**

19 NPIs in Jordan were effective in controlling the COVID-19 epidemic and reducing the  
20 reproduction rate. Early strict intervention measures showed evidence of containing and  
21 suppressing the disease.

1 **Declarations**

2 **Ethics approval and consent to participate:** Not applicable.

3 **Consent for publication:** Not applicable.

4 **Availability of data and materials:** All data generated or analyzed during this study are  
5 included in this published article [and its supplementary information files].

6 **Competing interests:** The authors declare that they have no competing interests.

7 **Funding:** None.

8 **Authors' contributions:** KK conceived the idea, prepared initial data for simulation, and drafted  
9 the initial manuscript. BA ran the simulation models, and prepared the initial methods and  
10 results. AA, MS, OM, MA, and FM critically evaluated the manuscript drafts and helped in data  
11 visualization.

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13 **Authors' information (optional):** Not applicable.

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1 **Table 1: Model Parameters' Description and Values Used for Simulating the Number of**  
 2 **COVID-19 cases in Jordan.**

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<b>Parameter and Symbols</b>	<b>Description</b>	<b>Scenario 1 Values</b>
$\beta$ (beta)	Transmission rate	February 1 to March 17 = 0.37 March 17 to April 24= 0.06 April 25 to May 15= 0.20 After May 15= 0.37
$\alpha$ (alpha)	Percentage of isolated infectious Symptomatic (moderate to Severe).	0.5
$\epsilon$ (epsilon)	Incubation period from exposed to infectious	5.2 days
$P_s$	Probability of developing severe SAR-COV-2 symptoms	0.01
$\mu$ (mu)	Recovery rate	14 days
$R_0$	Reproduction rate	5.6

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1 **Figure Legends**

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3 **Figure 1: Simulated COVID-19 epidemic curves in Jordan under scenarios 1 and 2 (S1**  
4 **and S2), utilizing the pre-symptomatic compartmental state.**

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6 **Figure 2: Simulated number of daily new COVID-19 cases in the mild compartmental state**  
7 **under scenario 1 (S1).**

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9 **Figure 3: Simulated number of daily new COVID-19 cases in the moderate to severe**  
10 **compartmental state under scenario 1 (S1).**

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12 **Figure 4: Number of daily new reported COVID-19 cases compared to S1-simulated**  
13 **numbers in the three compartmental states.**

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1 **Additional Files**

2

3 **Additional File 1:**

4 **File Format:** PDF

5 **Title of Data:** Table

6 **Description of Data:** Model Parameters' Description and Values Used for Simulating the

7 Number of COVID-19 cases in Jordan under the hypothetical scenario of no-action (S2).

8

9

10 **Additional File 2:**

11 **File Format:** PDF

12 **Title of Data:** Simulated COVID-19 epidemic curves in Jordan under scenarios 1 and 2 (S1 and

13 S2), utilizing the (A) mild, and (B) Moderate to severe compartmental states.

14 **Description of Data:** The simulated daily new mild COVID-19 cases under S1 peaked, on

15 March 21, at 36 cases and a total duration of 49 days. After which, the simulated daily new mild

16 case count started to decrease and reached, on April 27, zero daily new cases (total duration of

17 the epidemic curve was 87 days). Estimated cumulative mild case count has reached its

18 maximum at 794 case around April 27. Under S2, the curve peaked at 174,082 cases around

19 July 1st (a total of 151 days). The simulated daily new moderate to severe cases (S1) reached a

20 maximum number on March 24 with a total of 46 case (a total of 53 days). The number of

21 simulated daily new moderate to severe cases then decrease to zero case on April 27 (total

22 number of days for the epidemic was 87 days). Under S2, the curve peaked at a simulated daily

23 new cases of 150,523 on July 3 (a total of 153 days).

# Figures

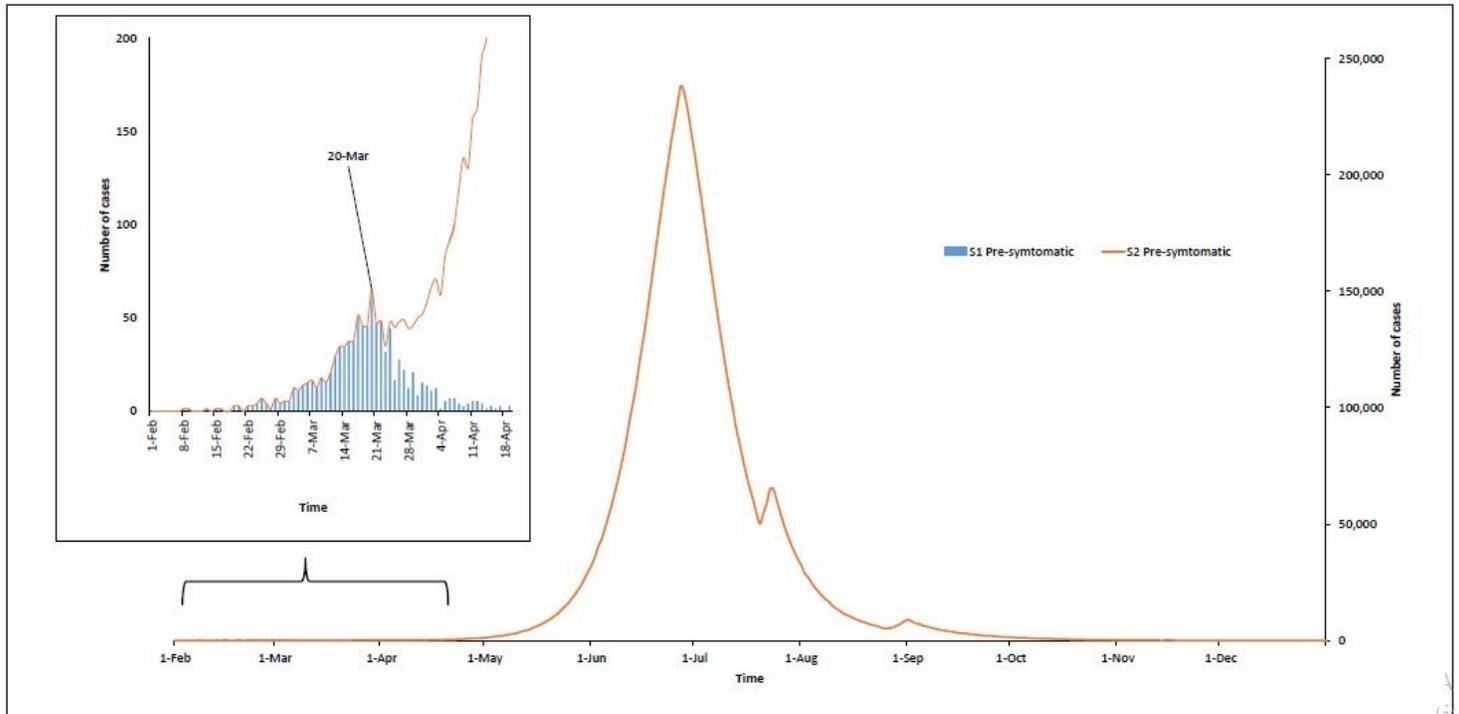


Figure 1

Simulated COVID-19 epidemic curves in Jordan under scenarios 1 and 2 (S1 and S2), utilizing the pre-symptomatic compartmental state.

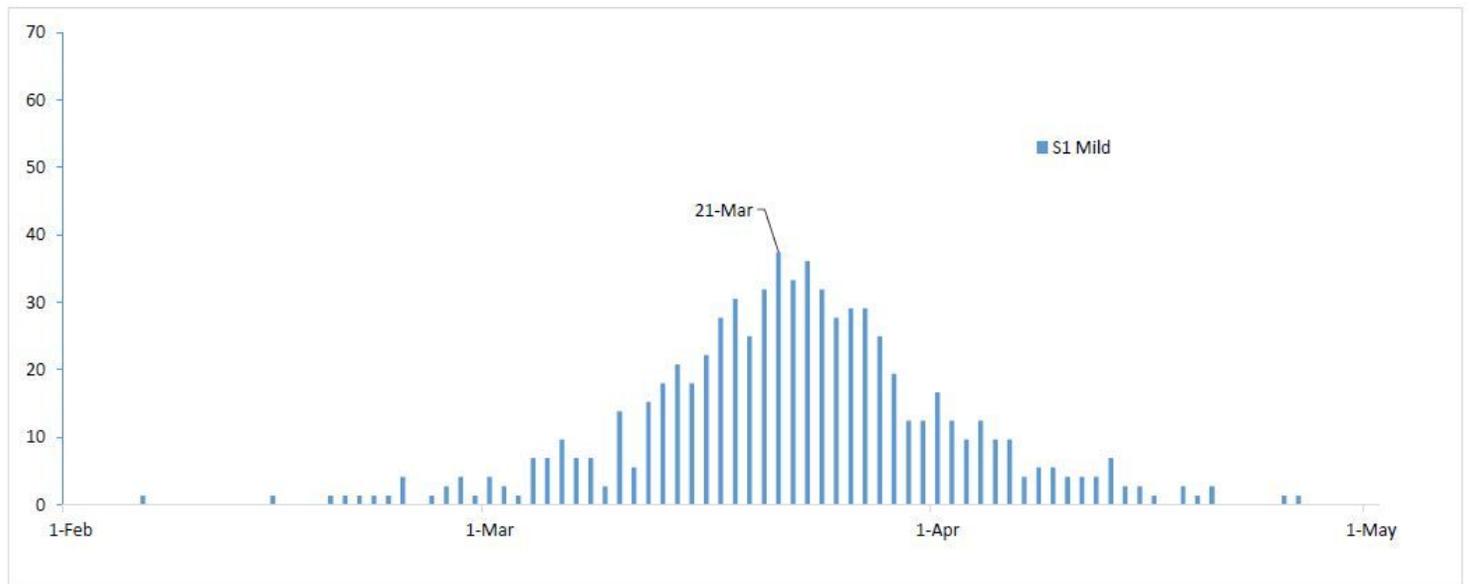
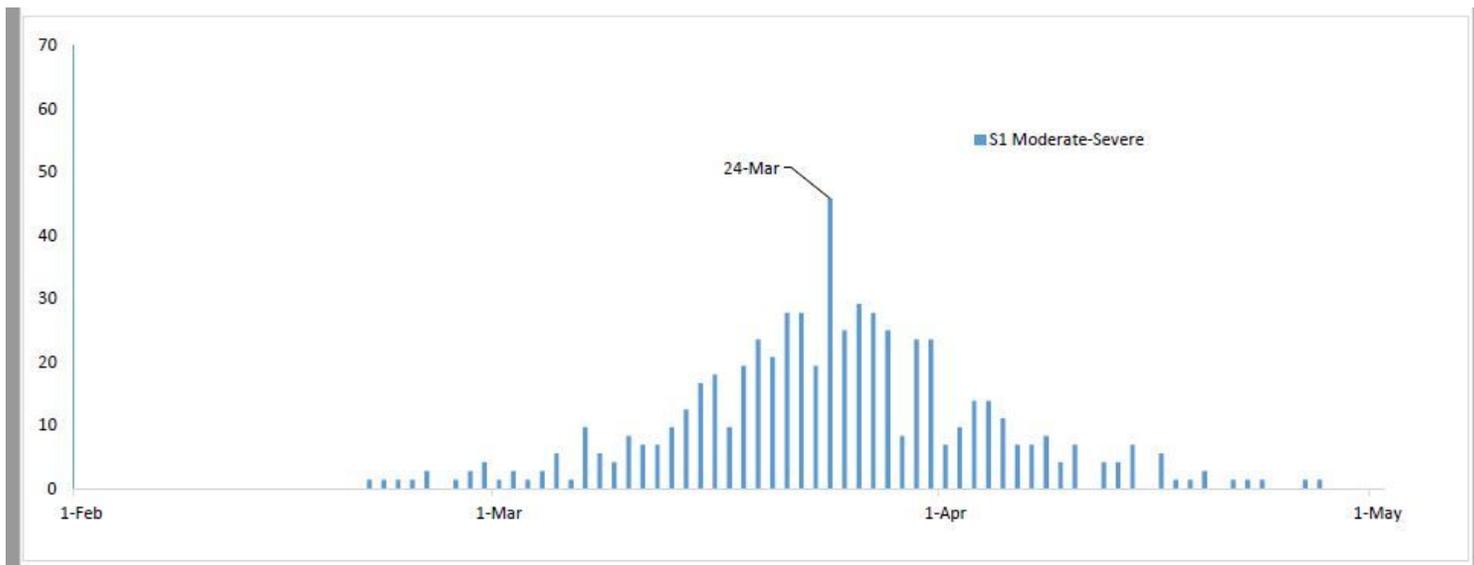


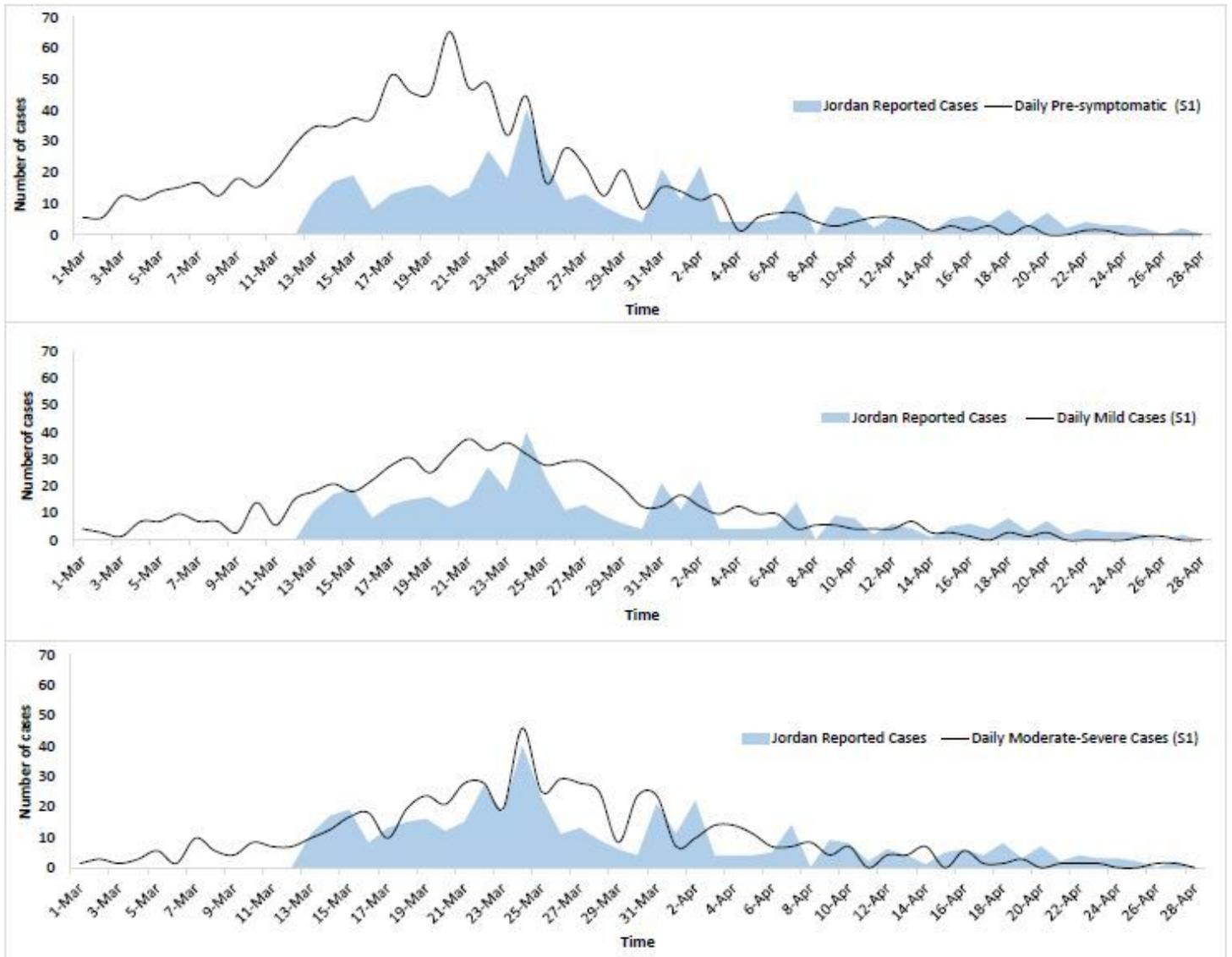
Figure 2

Simulated number of daily new COVID-19 cases in the mild compartmental state under scenario 1 (S1).



**Figure 3**

Simulated number of daily new COVID-19 cases in the moderate to severe compartmental state under scenario 1 (S1).



**Figure 4**

Number of daily new reported COVID-19 cases compared to S1-simulated numbers in the three compartmental states.

## Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

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