The Estimation of Newly Infected Cases of Covid-19 with Consideration of Governmental Action and Behavior of People in Iran

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ABSTRACT

The Novel severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) has caused 414179 infected cases and 18440 deaths up to March 25, 2020. The aim of this study was to estimate the new cases of COVID-19 in future days in Iran based on multiple factors such as governmental actions and people's behavior. We constructed the model based on governmental actions, people's behavior and lag time for governmental action. We estimated the governmental actions ratio and people's behavior with minimum sum square error with OptQuest arena software. By estimation the new cases under three scenarios for governmental actions, we predicted the new cases and cumulative death for different genders for all scenarios. Based on the first scenario, the maximum number of newly infected cases was 3117. Total cumulative death for 110th day for males and females respectively was 3157 and 2285. According to the second scenario, the maximum number of newly infected cases was 3117. Total cumulative death for 151st day for males and females respectively was 3504 and 2536. By selecting the third scenario, there were two peak points. In the first peak point, the maximum number of newly infected cases was 3117. In the second peak, the maximum number of newly infected cases was 3190. Based on the result of this study, it seems that the best option for the government is to keep social distance and close economic activity, so the number of new cases will be decreased.

Keywords: Coronavirus, COVID-19, Newly infected cases-governmental action, Model simulation, Behavior of people

Introduction

The Novel severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) has caused 414179 infected cases and 18440 deaths up to March 25, 2020 [1]. The most common symptoms were fever, fatigue, cough, sore throat, and myalgia [2]. Ground glass opacity and bilateral patchy shadowing were the common radiographic patterns in the chest CT [3]. Hypertension, diabetes, and coronary heart disease were the most frequent underlying disease in patients with SARS-CoV-2 [4]. The SARS-CoV-2 has a higher mortality rate than influenza, 3·7% against less than 1% [5].

According to the recent studies, the number of patients with coronavirus disease 2019(COVID-19) increased in Iran and caused this country to become one of the most prevalent of this disease out of china. In Iran, the number of patients with COVID-19 was 44495 with 2757 number of deaths up to March 31, 2020 [6].

This study aimed to estimate the new cases of COVID-19 in future days in Iran based on multiple factors such as governmental actions, people's behavior, and lag time of governmental action. At first, we explain the concept of the model. In the second part, we explain how the behavior of people and governmental action estimated with OptQuest arena software. In the third part, we explain the validation of our model. In the fourth part, the estimation of parameters was

explained. In the fifth part, we defined three scenarios for governmental action and analyze each one. By the result of this study, we can predict the future of this disease in Iran and make a proper decision to control or minimize the mortality rate at least.

Materials and methods

A conceptual model

We got help from the dynamic model transmission rate, which was conducted by lins [7] for the estimation of new cases each day. In this model, g_0 represented the ratio of new cases on the second day to new cases on the first day. The $N, NC, \widehat{NC}$ described the total population of countries, real new infected cases in each day [8], estimation of newly infected cases in each day. The D indicated the cumulative number of new infected cases for each days. The α showed the effect of the action of government on newly infected cases that has amount between zero to one. These effects can be closing schools or universities and decreasing office time to lessen the newly infected cases. The k showed the intensity of response which was related to the behavior of people for preventing the disease such as washing their hands or using a mask. The l represented a lag time for government action which obtained from the summation of incubation period and delay from onset to isolation. Model equation (1) as follows:

$$\widehat{NC}(t) = \widehat{NC}(t-1)g_0(1-. \alpha(t-l))(1-\frac{D}{N})^K \quad (1)$$

The behavior of people and the actions of the government had an important role in this model. We assumed the effect of governmental action is zero during 11-22 February 2020 because the government had no action for preventing the issuance of the disease in this period. From 23 February 2020 until 25 March 2020, we assumed governmental action was between $\alpha=0\cdot05$ and $\alpha=0\cdot3$ because, in this period, the government forced to close the school, the university, and decreased office time. Also, from 26 March 2020

to 9 April 2020, we assumed governmental action was between $\alpha=0\cdot30$ and $\alpha=0\cdot40$ because the government implemented social distancing and all marketing was closed. Due to the lack of information from the behavior of Iranian people, we assumed the lag time was between 100 and 500, which was obtained from the summation of the incubation period and the delay from onset to isolation[9]. The population of Iran was 83992949, so we considered the N equal to 83992949. Since newly infected cases for the second day were equal to three and newly infected cases were equal to two. In this case, the g_0 was equal to $1\cdot5$. For estimation of governmental action for 23 February 2020 to 25 March, 26 March 2020 to 9 April 2020, and behavior people parameter, we use sum square error as following:

$$SSE = (NC - \widehat{NC}(\alpha. k))^2 \quad (2)$$

Estimation parameters

The following process has been followed for parameters estimation:

- At first, we constructed the model in Arena software simulation as demonstrated in Figure 1.
- We imported real newly infected cases data from 11 February to 4 April by the ReadWrite Arena module in order to calculate SSE.
- After modeling in OptQuest Arena, the governmental action of two periods and behavior of people was defined as a discrete control variable. Subsequently, the SSE was defined as an objective function that should be minimized.
- Discrete step size for governmental action was defined 0.01 and Discrete step size for behavior people was defined 1.

The best value for SSE was 5288487, which was indicated in Figure 2. The governmental action for 23 February 2020 to 25 March 2020 and 26 March 2020 to 9 April 2020 and behavior people for this SSE consequently were 0.75, 0.7, and 184.
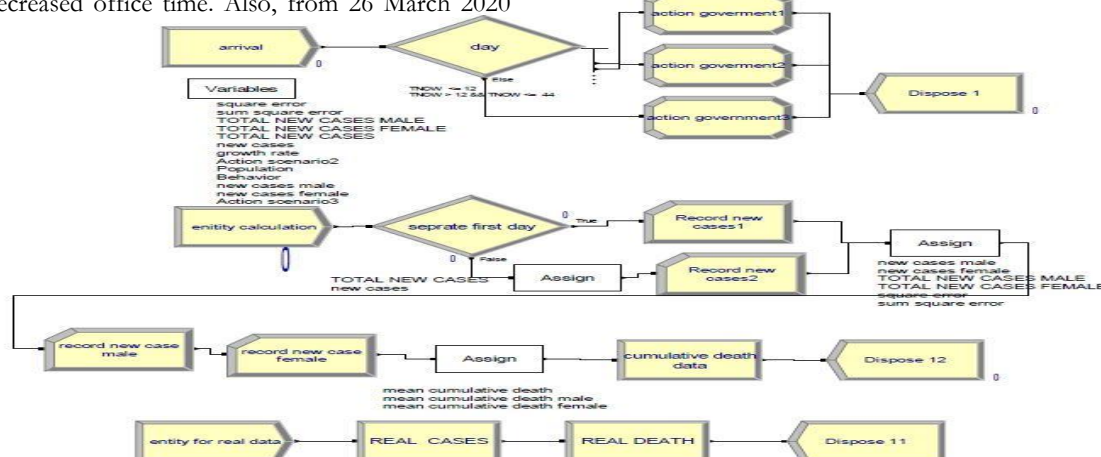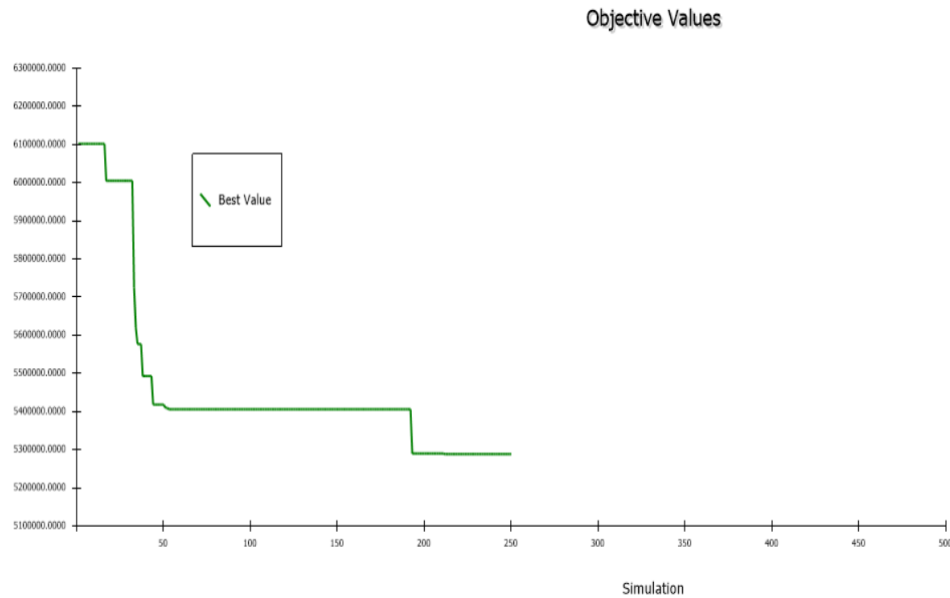

Figure 1. Model.

Figure 2. Finding best value for MSE with different value for governmental action and people's behavior.

A conceptual model

The estimation of newly infected cases multiple by 58·4 which was reported by the ministry of health [9] to obtain the newly infected cases for females and males. Besides, for the estimation of cumulative death each day, we calculated a ratio for each day, which obtained by dividing real cumulative new death to real cumulative infected cases each day. These ratios obtained from February 19 to April 4, 2020, and these ratios from 19 February to 24 February were removed. The average ratios from February 25 to April 4, 2020, were equal to 0·06316. Then, these ratios multiplied by cumulative estimation infected for each day in each sex.

Validation model

In order to check the adequacy of the current model, we collected real newly infected cases and cumulative death data from 3 April to 30 May. Furthermore, we assumed the governmental action was equal to 0.25 from 10 April to 18 April because the government decided to open offices and markets but in a limited way. After 18 April, the governmental action was changed and was equal to 0.14 because the government decided to gradually increase office and market time. Then, the estimated newly infected cases and real newly infected cases were plotted together in Figure 3. In addition, the estimated cumulative death and real cumulative death were plotted in Figure 4. As shown in Figure 3, the new infected cases decreased until 69 days in simulated model, and also, real new cases decreased until 72 days and again both of them increased. For cumulative death, as shown in Figure 4, both estimation cumulative death and real cumulative death grew together and crossed each other in two points.
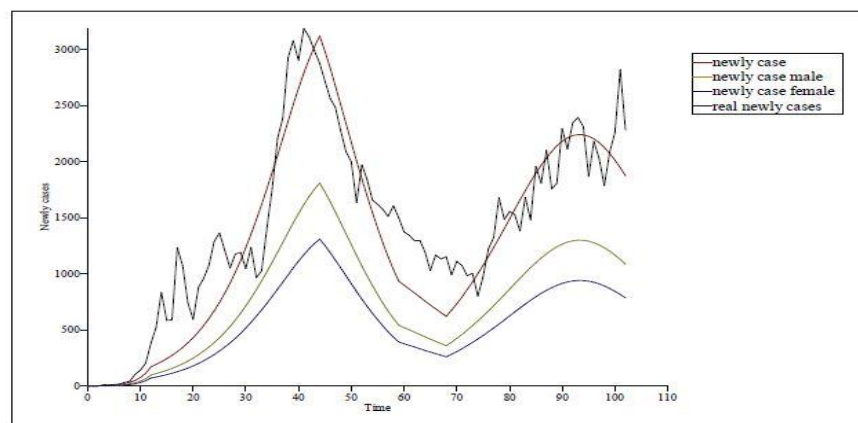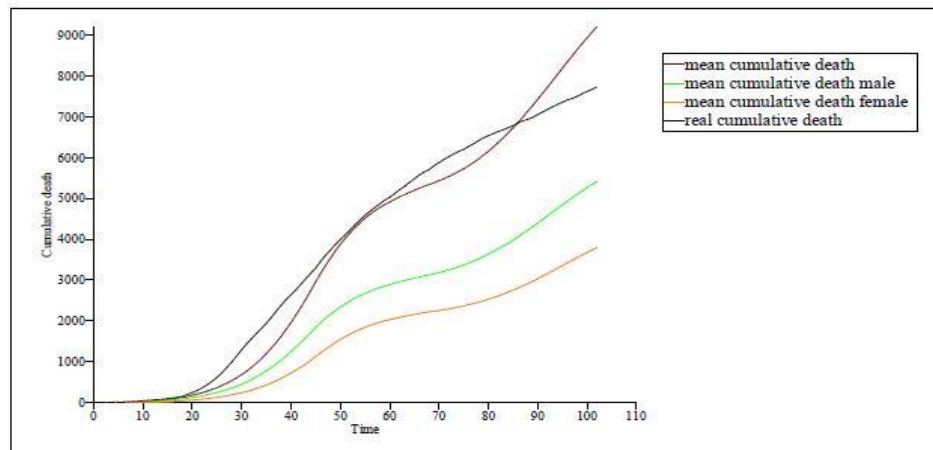

Figure 3. New infected cases for validation model.

Figure 4. Cumulative death for validation model.

Model simulation and sensitive analysis

We studied three scenarios. In the first scenario, we studied what if the government decided to continue implementing social distancing and keep close marketing after 4 April. In the second scenario, we studied what if the government decided to decrease office time, close school, and university after 17 April (the same action was done by the government from 23 February to 25 march). In the third scenario, we studied what if the government decides to return all economic activities to usual condition after 30 May (the same action was done by the government from 11 February to 22 February).

Results

Based on the first scenario that was shown in Figure 5, we had a maximum point and this point was estimated 3117 newly infected cases, which were related to the 44th day. In this day, newly infected cases for male and female respectively was 1808 and 1309. Also, the number of newly infected cases decreased and for 110th day, these new cases reached 0. Total cumulative death for the 110th day for males and females respectively was 3157 and 2285 Figure 6.

According to the second scenario that was shown in Figure 7, we had a maximum point and this point was estimated 3117 newly infected cases, which were related to the 44th day. In this day, newly infected cases for male and female respectively was 1808 and 1309. After the 59th day, newly infected cases decreased slower than the first scenario. In the 151st day, these new cases reach to zero. Total cumulative death for 151st day for males and females respectively was 3504 and 2536 Figure 8.

In the third scenario that was indicated in Figure 9, we predicted another peak point. In the second peak, the maximum number of newly infected cases was 3190, which was related to the 125th day. In this day, newly infected cases for male and female respectively was 1850 and 1339. After 125th day, newly infected cases decreased and in the 130th day, these new cases reached 2886. Total cumulative death in the 130th day for males and females respectively was 8124 and 5684 Figure 10.
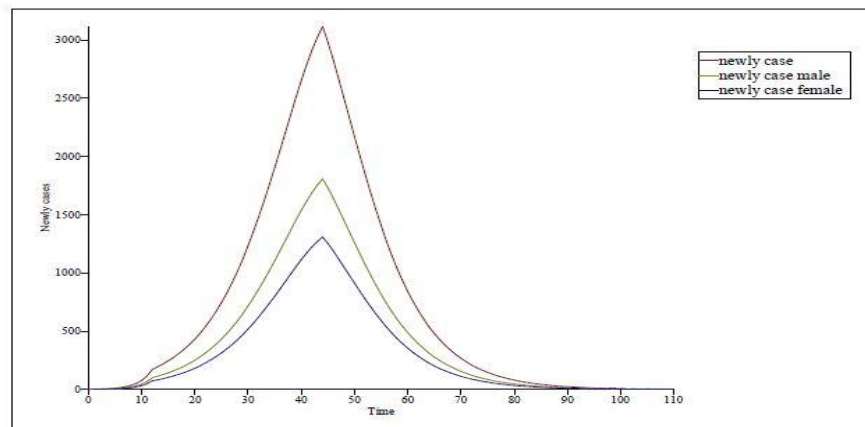

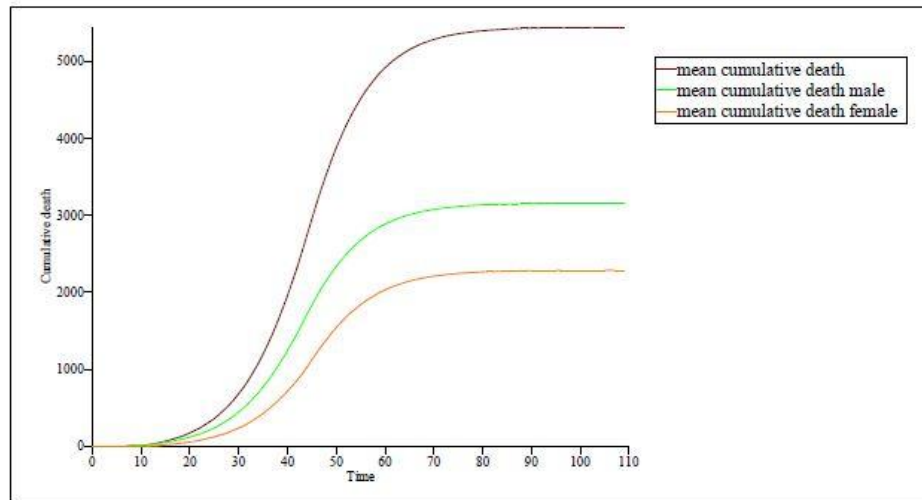**Figure 5.** New infected cases for scenario 1.
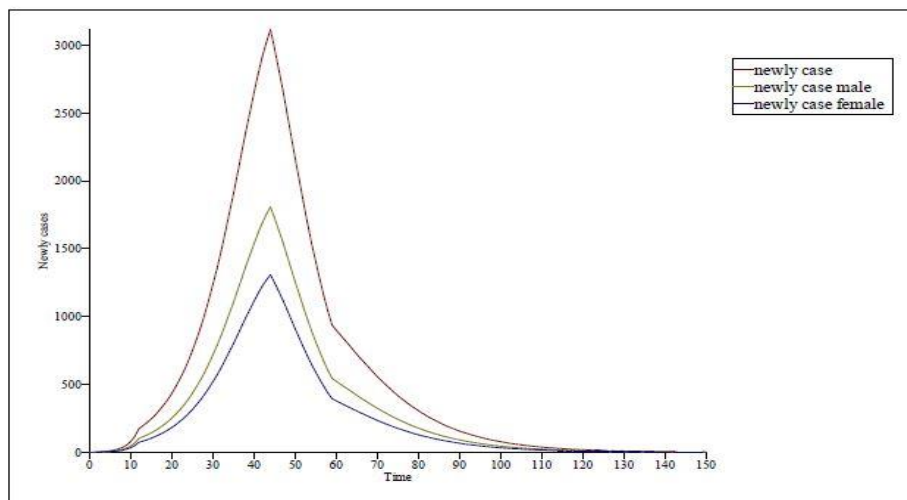
Figure 6. Cumulative death for scenario 1.

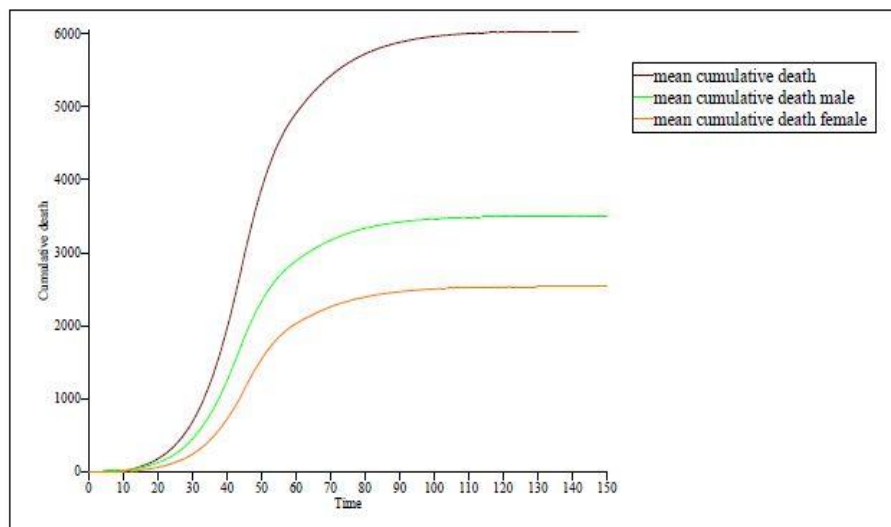**Figure 7.** New infected cases for scenario 2.

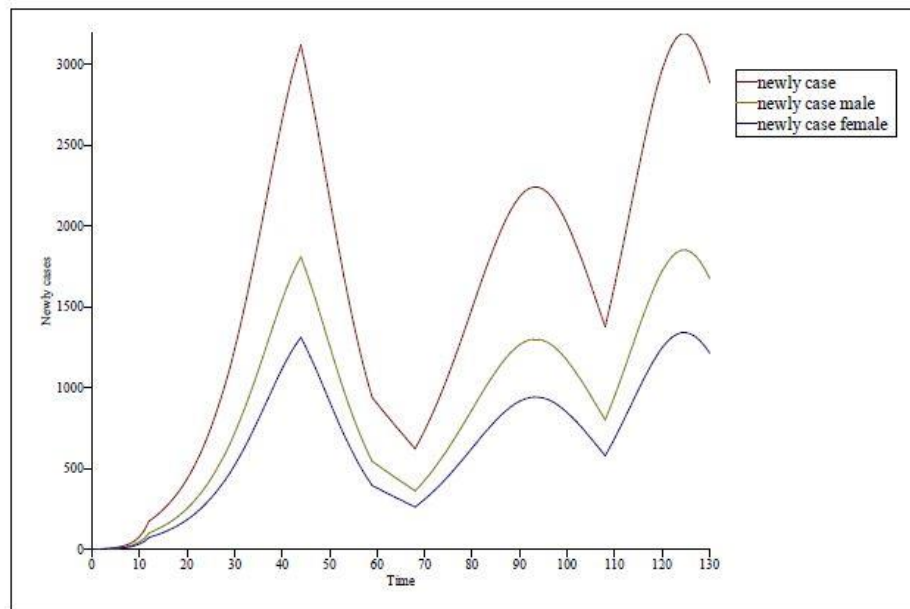**Figure 8.** Cumulative death for scenario 2.

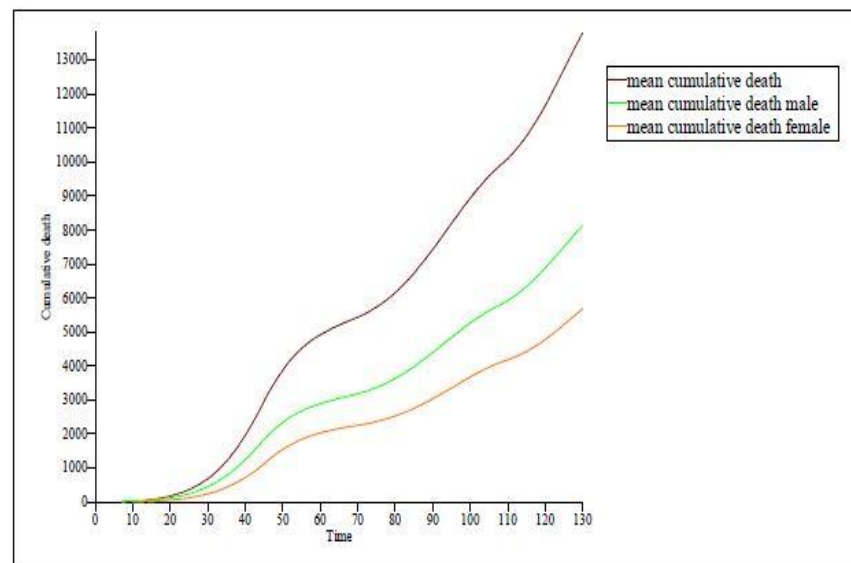**Figure 9.** New infected cases for scenario 3.

Figure 10. Cumulative death for scenario 3.

Discussion

We used governmental action and intensity of responds factors from the model of Lins [7] and Daihai [10] in our model. We chose the initial growth rate in our model which was not used in the model of Lins [7] and Adam [11]. Furthermore, we considered a lag time for the governmental action which was including the incubation period and the delay from the onset to isolation. These factors were not considered in the model of Lin. Also, our model was related to Iran which had a population of 83 million, but the model of

Lin and Adam [11] was used for Wuhan which had a population of 11.08 million. We estimated the newly infected cases based on gender which was not mentioned in the model of Lins, Adam, Fairoza, Amira, and Binti Hamzah [7, 11, 12]. Because of the lack of information for the effect of temperature on the activity of Covid-19, we did not consider the effect of temperature in our model. Our result indicated that if the government chooses the first scenario and implements a social distancing plan, newly infected cases approximately will be finished after 110 days. On the other hand, if the government chooses the second

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scenario and just closes universities and schools and decrease office time, newly infected cases declined after 59 days but slower than the first scenario. In the third scenario, the government faces the second peak of newly infected cases, which was a little more than the first peak. So according to the first scenario, newly infected cases decreased fast and all economic activities can be opened after the 110th day. But in the third scenario, due to the second peak, the government faces with lack of capacity and human resources in hospitals.

Conclusion

Due to increase the number of newly infected cases and lack of capacity in hospitals, the government should not remove the restrictions and should execute the first scenario in order to decrease the newly infected cases very fast. Implementing second scenario is not wise choice because duration of pandemic increase and behavior of people about health protocols may be changed, therefore the newly infected cases increase again.

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