

Mathematical Modeling and Simulation of SIR Model for COVID-2019 Epidemic Outbreak: A Case Study of India

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Abstract: The present study discusses the spread of COVID-2019 epidemic of India and its end by using SIR model. Here we have discussed about the spread of COVID-2019 epidemic in great detail using Euler's method. The Euler's method is a method for solving the ordinary differential equations. The SIR model has the combination of three ordinary differential equations. In this study, we have used the data of COVID-2019 Outbreak of India on 8 May, 2020. In this data, we have used 135710 susceptible cases, 54340 infectious cases and 1830 reward/removed cases for the initial level of experimental purpose. Data about a wide variety of infectious diseases has been analysed with the help of SIR model. Therefore, this model has been already well tested for infectious diseases by various scientists and researchers. Using the data to the number of COVID-2019 outbreak cases in India the results obtained from the analysis and simulation of this proposed SIR model showing that the COVID-2019 epidemic cases increase for some time and there after this outbreak decrease. The results obtained from the SIR model also suggest that the Euler's method can be used to predict transmission and prevent the COVID-2019 epidemic in India. Finally, from this study, we have found that the outbreak of COVID-2019 epidemic in India will be at its peak on 25 May 2020 and after that it will work slowly and on the verge of ending in the first or second week of August 2020.

Keywords: SIR Model, Euler's Method, Differential equations, Coronavirus, COVID-19 data set of India, SARS-CoV-2 Epidemics, Social distancing, Lockdown.

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1 Introduction

Today, the corona virus epidemic has emerged as an important challenge in front of the whole world. COVID-19 has about 3588777 confirmed cases and 247503 deaths as of May 6, 2020 [1]. Almost the entire population of the world is currently using lockdown, social distancing and masks to stop this epidemic. India is also using such resources to fight this epidemic at the moment. The COVID-19 epidemic is a member of SARS-Cov-2 family. No medicine has been prepared for this disease yet. COVID-2019 is an epidemic spread from one human to another at a very rapid speed due to the breathing or contact of an infected person.

Hence COVID-2019 is a contagious disease. The incubation period of this disease is 2 to 14 days. In a recent study, it has been found that the overall mortality

rate of COVID-19 epidemic is estimated at about 2-3%. This disease proves fatal for people above 60 years. The overall mortality rate for people above 40 years of age is about 27% [2-3]. In India, on January 20, 2020, a patient of COVID-19 was found. This person came to Kerala of India from Wuhan city of China. The first case of COVID-19 was found at the end of November 2014 in Wuhan city of China. After 30 January 2020, the corona virus slowly spread in whole India.

On 19 March 2020, the Prime Minister of India, Narendra Modi announced the janata curfew on 22 March 2020. After this, the Prime Minister gave lockdown to India all over India till 14 April 2020. Even after lockdown in India, COVID-19 epidemic patients continued to grow. Today, according to COVID-19 epidemic data in India which was available on Indian council of medical research (ICMR) website, 81970 are infected, 27920

were cured and 2649 people died on 15 May 2020. However, India has a much larger population density than other countries and apart from this; medical facilities are not available in sufficient quantity. Therefore, the risk of spreading corona virus is very high here. Despite all these, corona infection in India is very less compared to other countries. In recent studies, it has been found that the cause of corona virus infection in India is low due to warm climate as well as humidity [4-5], Bacille Calmette-Guérin (BCG) vaccination and a large amount of young population [6]. Due to all this reasons, the resistance of people here is very high compared to other countries. All these studies are preliminary studies and no scientific evidence of this type of study is available till now [7]. Hence there is a need to study COVID-2019 outbreak with more evidence now. In this study we have presented an epidemic model based on SIR method of COVID-19 spread to India. Most epidemics have an initial exponential curve and then gradually flatten out [8]. In this proposed study, we have also considered the effects of social distancing on the growth of infections, lockdown and face mask India. India announced a countrywide lockdown on 24 March 2020 for 21 days although a study has suggested that this period may be insufficient for controlling the COVID-19 pandemic [9]. In the present study, we have assumed the effects of social distancing measures, lockdown and face cover from the time of spread to India.

Hence there is a need to study COVID-2019 with more evidence now. In this proposed study, we have presented an epidemic model based on SIR method of COVID-19 spread to India. The proposed SIR model has three differential equations. The solution of such type of differential equation is difficult and time consuming. Therefore we have used Euler’s method for solving these three differential equations. Most epidemics have an initial exponential curve and then gradually flatten out.

The objectives of these studies are given below:

1. Finding the rate of spread of the disease with help of SIR model.
2. The development SIR model for exposed COVID-2019 outbreak at peak in India.
3. Forecast of COVID-2019 outbreak of India with next days, months even a year for better management for doctors and various government organizations.
4. For find out the ending stage of COVID-2019 outbreak in India.

2 SIR Model

In this proposed study, we have considered an epidemic model which was developed by Kermack and McKendrick in 1927 [10]. This epidemic model is also known as SIR (Susceptible, Infective and Recover/Removed) epidemic model. This model have

already used successfully in several outbreak diseases like Avian influenza, Cholera, SARS, Ebola, Plague, Yellow fever, Meningitis, MERS, Influenza, Zika, Rift Valley Fever, Lassa fever, Leptospirosis [11, 12, 13, 14,15]. The SIR model is very useful for future prediction, end and peak of epidemic disease and other related activity of outbreak diseases [12].

Let us consider the population of India remains constant regarding the study COVID-2019 outbreak in India. Here, we have chosen all COVID-2019 tested population of India on 7 April 2020. In this proposed study, we have total COVID-2020 tested population is divided into three parts:

1. $S(t)$: The number of susceptible population at time t i.e. number of total COVID-2019 tested population till 7 April 2020.
2. $I(t)$: The number of infectives population at time t , i.e. number of infected COVID-2019 population of India till 7 April 2020.
3. $R(t)$: The number of recovered population at time t , i.e. number of recovered or died or naturally immune to the disease COVID-2019 population of India till 7 April 2020.

In this proposed study, we have take $R(t)$ is equal to the recovered population plus died population from COVID-2019 outbreak of India on 7 April 2020 for the sake of simplicity of this study [16]. Figure 1 shows the description of proposed SIR model for not considering virus evolution.

This model does not consider the development of COVID-2019 like most of the diseases [17-20]. But, in contrast my proposed SIR model which is shown in figure 2 does consider the development of COVID-2019 outbreak of India. This model also predicts maximum growth of COVID-2019 outbreak in India. Figure 2 shows the description of SIR model for recovered re-tuning into susceptible because the COVID-2019 outbreak of India has evolved into one which can re-infect.

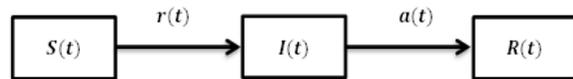


Figure 1: Description of SIR model not considering COVID-2019 outbreak virus evolution

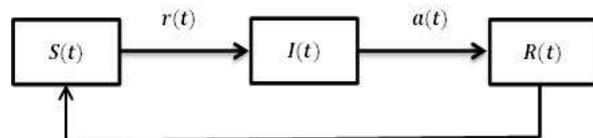


Figure 2: Description of SIR model considering COVID-2019 outbreak virus evolution

3 Methodology of SIR Model

Let us consider the following three differential equations are used for experimental studies and experimental discussion for COVID-2019 of India. The description of these three differential equations is given below:

$$S'(t) = -rSI \quad (1)$$

$$I'(t) = rSI - aI \quad (2)$$

$$R'(t) = aI \quad (3)$$

The parameters r and a of above differential equations are known as the infection rate and recovery/removal rate of COVID-2019 of India. In this proposed study the average time of COVID-2019 outbreak of India is approximately 14 days. These numerical values of r and a are very useful in initial level for solving the three differential equations of COVID-2019 outbreak of India.

The three differential equations (1), (2) and (3) of the proposed SIR epidemic model for COVID-2020 outbreak of India can be also written as [12]:

$$\frac{dS}{dt} = -rSI \quad (4)$$

$$\frac{dI}{dt} = rSI - aI \quad (5)$$

$$\frac{dR}{dt} = aI \quad (6)$$

These three differential equations of SIR model is known as Kermack-McKendrick [12] SIR model. At the present time, this model is very useful for the data analysis of COVID-2019 in India. Again adding equation number (4), (5) and (6), we can get another very useful expression for COVID-2019 data analysis. This expression is given below:

$$\frac{dS}{dt} + \frac{dI}{dt} + \frac{dR}{dt} = -rSI + rSI - aI + aI = 0$$

$$dS + dI + dR = 0 \quad (7)$$

After integrating equation number (7), we can get the following relation for calculating the total population of COVID-2019:

$S' + I' + R' = N$, where N is known as the constant of integration which is measure the total size of population for COVID-2019 at initial level and after end the epidemic COVID-2019 in India. This is constant population at all levels of COVID-2019 outbreak. The above expression $S' + I' + R' = N$ can be also denoted by in the following form:

$$S(t) + I(t) + R(t) = N \quad (8)$$

For the experimental purpose of data analysis of COVID-2019 outbreak of India, we can take the following initial values of proposed SIR model, i.e.

$$S(0) = S_0, I(0) = I_0 \text{ and } R(0) = R_0$$

Here the population size of India is constant. We can calculate the recovered population of COVID-2019 outbreak of India which given by the following formula:

$$R(t) = N - (S(t) + I(t)) \quad (9)$$

The above three differential equations (4), (5) and (6) of the proposed SIR model can be converted into two differential equations equation number (9). The solution of these two differential equations is very difficult and time consuming. But the solution is very necessary of these two differential equations for data analysis of

COVID-2019 outbreak of India. In this proposed study, we have used quantitative approach for solving these two differential equations of SIR model.

Now, here we can say that if S' is less than zero for all t and if I' is greater than zero as long as the initial population (say the number of susceptible cases in India on 7 May 2020) S_0 is greater than the ratio, $\frac{a}{r}$. In other words, we can say that we will initially increase to some maximum if initial population S_0 is greater than the ratio $\frac{a}{r}$, but eventually it must decrease and approaching to zero because S_0 decreasing. In this proposed study, we have introduced some cases for COVID-2019 outbreak of India, which is given below:

Case-1: If S_0 is less than the ratio, $\frac{a}{r}$ then the infection I of COVID-2020 outbreak of India will be decrease or simply to be zero after some times.

Case-2: If S_0 is greater than the ratio $\frac{a}{r}$ then the infection I of COVID-2020 outbreak of India will be epidemic of COVID-2019.

These are the assumptions of SIR model regarding the COVID-2019 outbreak of India. Therefore from the above two assumptions, we can say that the behaviour of COVID-2019 outbreak of India depends on the values of following expression:

$$R_n = \frac{S_0 r}{a} \quad (10)$$

This quantity is known as the threshold number. In this present study we have defined another quantity called reproductive number which is denoted by R_n and defined by the following expression (10). This is the number of secondary infectives of COVID-2019 outbreak produced by one primary infective in the susceptible populations. Here, there are two cases of COVID-2019 of India regarding reproductive number:

Case-1: If R_n is less than one then COVID-2019 outbreak will be does out from India..

Case-2: If R_n is more than one, then the outbreak of COVID-2019 is still in epidemic form in India.

3.1. Phase Plan and Experimental Results

There is an absolute need to solve the differential equation of the proposed the SIR model for analysis of COVID-2019 outbreak of India. Let us consider a population of susceptible of COVID-2019 outbreak and a small number of infected populations. Is the of COVID-2019 infectives populations increase substantially in India? The answer of this question will get after solving differential equations of (4), (5) and (6). The differential equations (4), (5) and (6) is system of differential equation and these equations have three unknown. These systems of differential equations are very difficult to solve. Although, after combining the equation (4) and (5) then we get the single differential equation with one

unknown for the proposed SIR model. The procedure is as follows:

According to the chain rule calculus:

$$\frac{dI}{dS} = \frac{(dI/dt)}{(dS/dt)} = \frac{rSI - aI}{-rSI} = \frac{rSI}{-rSI} - \left(\frac{aI}{-rSI}\right) = \frac{a}{rS} - 1$$

$$\frac{dI}{dS} = \frac{a}{rS} - 1$$

$$dI = \left(\frac{a}{rS} - 1\right) dS$$

Integrating both sides of above equation, we get

$$\int dI = \int \left(\frac{a}{rS} - 1\right) dS$$

$$I = \frac{a}{r} \ln(S) - S + C \quad (11)$$

Where, C is the arbitrary constant.

$$\text{And } R = N - I - S \quad (12)$$

This Karmack-Mchendrick SIR model is equipped with the initial conditions. We take the initial conditions which are given below:

$S(0) = S_0$ and $I(0) = I_0$ then the equation (11) becomes:

$$I_0 = \frac{a}{r} \ln(S_0) - S_0 + C \quad (13)$$

$$C = I_0 + S_0 - \frac{a}{r} \ln(S_0) \quad (14)$$

Let us consider the population size of susceptible case of COVID-2019 outbreak of India is K . This is approximately equal to initial population S_0 of India. Here, we will introduce a small number of infectives in the population. Therefore,

$$S_0 = K, I_0 = 0 \text{ and } R_n = \frac{rK}{a}$$

If $I(t) = 0$ as $t \rightarrow \infty$ and $S_0 < \frac{a}{r}$ then $V(S_0, I_0) = V(S_0)$, gives the following expression:

$$K - \frac{a}{r} \ln(S_0) = S_\infty - \frac{a}{r} \ln(S_\infty)$$

Where S_∞ is the susceptible population of India if infectives case will be zero. After simplification of above expression, we will get the following expression:

$$K - S_\infty = -\frac{a}{r} \ln(S_\infty) + \frac{a}{r} \ln(S_0)$$

$$K - S_\infty = \frac{a}{r} \ln(S_0) - \frac{a}{r} \ln(S_\infty)$$

$$K - S_\infty = \frac{a}{r} [\ln(S_0) - \ln(S_\infty)]$$

$$K - S_\infty = \frac{a}{r} \ln \left[\frac{S_0}{S_\infty} \right]$$

$$\frac{r}{a} = \frac{\ln \left[\frac{S_0}{S_\infty} \right]}{K - S_\infty} \quad (15)$$

Here $0 < S_\infty < K$ that is part of the population of India escapes the COVID-2019 infective. In this proposed study, it is very difficult to estimate the parameters of r and a because these are depends on disease being studies and on social and behavioral factors of that country. The population S_∞ and S_0 can be estimated by serological studies before and after of the COVID-2019 outbreak and using this data, the basic reproduction number is given by the following formula:

$$R_n = \frac{rK}{a}$$

$$(16)$$

This expression can be calculated using expression (15). The maximum number of COVID-2019 outbreak infectives at any time in India can be obtained by substantially using the following calculation:

Putting $S = \frac{a}{r}$ and $I = I_{max}$ in equation (11), we get the maximum number of infective case of COVID-2019 outbreak in India at any time.

$$I = \frac{a}{r} \ln(S) - S + C$$

Where, $C = I_0 + S_0 - \frac{a}{r} \ln(S_0)$

Therefore the maximum number of infectives cases I_{max} of COVID-2019 outbreak of India can calculated with the help of following expression:

$$I_{max} = I_0 + S - \frac{a}{r} + -\frac{a}{r} \ln(S_0) + \frac{a}{r} \ln \left(\frac{a}{r} \right) \quad (17)$$

The differential equation of the proposed SIR model can be solved with help of many numerical methods such as Runge Kutta and Euler methods. Here we have used Euler method for solving SIR model based differential equation.

In this proposed study, we have used the MATLAB software for solving the differential equation using the above initial conditions values of S_0, I_0, R_0, a and r . The experimental results of SIR model is shown in table 1. Here, the numerical calculation and data analysis of COVID-2019 outbreak of India has been done with the help of Euler method.

Euler's method is purely numerical method for solving the first order differential equations. The SIR model has also system of first order differential equations. So, the Euler's method is more suitable for solving the proposed SIR based system of differential equations. The description of the Euler's method is given below:

Let consider the first order differential equation:

$$\frac{dy}{dx} = f(x, y) \quad (18)$$

The solution of differential equation (18) is given by the following expression:

$$y_{n+1} = y_n + \Delta t f(x_n, y_n) \quad (19)$$

Where Δt a small is step size in the time domain and $f(x_n, y_n)$ is the slope of the curve. Here, we want to calculate the dependent variable called S, I and R to the proposed SIR model. Therefore the solution of proposed SIR model based differential is converted into Euler method forms which are given below:

$$S(n+1) = S(n) - rI(n)S(n)\Delta t \quad (20)$$

$$I(n+1) = I(n) + [rI(n)S(n) - aI(n)]\Delta t \quad (21)$$

$$R(n+1) = R(n) + aI(n)\Delta t \quad (22)$$

In this proposed study, we have used COVID-2019 data set from India on 7 May 2020. Here, we have taken the total number of COVID-2019 tested population as S_0 , total number of infectives population as I_0 and total number of recovered/removed cases as R_0 at initial level

for analyzing the COVID-2019 outbreak of India on 7 May 2020. These three initial populations S_0 , I_0 and R_0 are represented as:

$$S_0 = 13.57410, I_0 = 0.56340, R_0 = 0.18430$$

The value of recovery rate/removal rate and infection rate of COVID-2019 outbreak of India can be calculated with the help by the following expression:

$$r = \frac{p}{q} = \frac{42836}{1357413} = 0.03156$$

Where p is Infected Population of India on 7 May 2020 and q is Susceptible Population of India on 7 May 2020 for COVID-2019.

$\frac{1}{a} = 14$, (Because the incubation time of COVID-2019 outbreak of India is 14 day)

$$a = \frac{1}{14} \approx 0.0714$$

$$\Delta t = 0.1407$$

Putting the values of Δt , r , a , S_0 , I_0 and R_0 in equation (20), (21) and (22) to get the next generation values Susceptible population S_1 , I_1 and R_1 ,

$$S_1 = S_0 - rI_0S_0\Delta t$$

$$S_1 = 13.57410 - (0.03156 \times 0.56340 \times 13.57410 \times 0.1407)$$

$$S_1 = 13.57410 - 0.03396$$

$$S_1 = 13.54014$$

$$I_1 = I_0 + (rI_0S_0 - aI_0)\Delta t$$

$$S_1 = 0.56340 + (0.03156 \times 0.56340 \times 13.57410 \times 0.1407 - 0.07143 \times 0.56340 \times 0.1407)$$

$$S_1 = 0.591698$$

$$R_1 = R_0 + aI_0\Delta t$$

$$R_1 = 0.18430 + 0.07143 \times 0.56340 \times 0.1407$$

$$R_1 = 0.1899622832434$$

$$R_1 = 0.18996$$

Similarly, we can calculate other iteration. The numerical results of Euler's method of SIR model is shown table 1. Figure 3 shows the simulation of proposed SIR Model for COVID-2019 epidemic state of India from 7-May 2020. This figure also shows that the date of the maximum number of infection cases of COVID-2019 in India is 25 May 2020 (see table 1 from bold column). The figure 4 shows the maximum number of infected cases of COVID-2019 outbreak of India. Apart from this, the figure 5 shows the recovered cases of COVID-2019 outbreak of India.

The maximum number of infectives cases (I_{max}) of COVID-2019 outbreak of India can be calculated using equation (17) is as follows:

$$a = 0.07143, K = S_0 = 13.57410, I_0 = 0.56340, S_\infty = 0.02260$$

Then the ratio $\frac{r}{a}$ can be calculated using equation (15) i.e. $\frac{r}{a} = 0.4602$. Therefore $r = 0.4602 \times 0.07143 = 0.32872086$.

Hence $I_{max} = 7.9835$. Here, we have multiply by 100000 in I_{max} to get maximum number of infectives

cases of COVID-2019 outbreak of India because 100000 is the normalization factor of this proposed study. Therefore $I_{max} = 7.9835 \times 10000 = 798350$ which is the real data pointing at 782000 in table 1. From this table, we have seen that maximum number of infectives cases of COVID-2019 is 782000. This value is near by the, I_{max} . Therefore, we have seen that there will be a maximum outbreak of COVID-2019 in India on 25 May 2020 and then it will decrease continuously till the first week of August 2020.

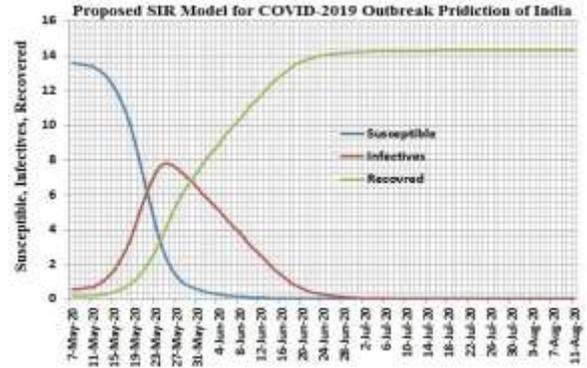


Figure 3: SIR Model Simulation for COVID-2019 epidemic of India from 7-May 2020

The reproductive number of COVID-2019 outbreak can be also calculated on initial, pick, end of COVID-2019 outbreak and any time during epidemic of COVID-2019 of India. Here, there are some reproductive number calculations are given below:

1. Initial level of COVID-2019:

$$R_n = \frac{rS_0}{a} = \frac{0.03156 \times 13.57410}{0.0714} = 6$$

2. Pick level (maximum of COVID-2019):

$$R_n = 13.57410 \times 0.4602 = 6.2468$$

$$\left(\frac{r}{a} = 0.4602, K = S_0 = 13.57410\right)$$

3. End level of COVID-2019:

$$R_n = 0.0226 \times 0.4602 = 0.001040$$

$$\left(\frac{r}{a} = 0.4602, K = S_\infty = 0.0226\right)$$

From above calculation, we have observed that the if reproductive number is greater than one then the COVID-2019 increasing continuously at pick/maximum level Case-1 and case-2) and if reproductive number is less than one then the COVID-2019 is died off (case-3). However, the reproduction number of COVID-2019 has been calculated by epidemiological scientists all over the world. In the study presented here, we get the following observations:

1. The outbreak of COVID-2019 will be at its peak on 25 May 2020 in India, after which the outbreak of this epidemic will continue to work slowly.
2. The outbreak of COVID-2019 in India will be till the first or second week of August 2020, after which the epidemic will end.

3. The initial stage of COVID-2019, the reproductive number of this outbreak of India is 6.

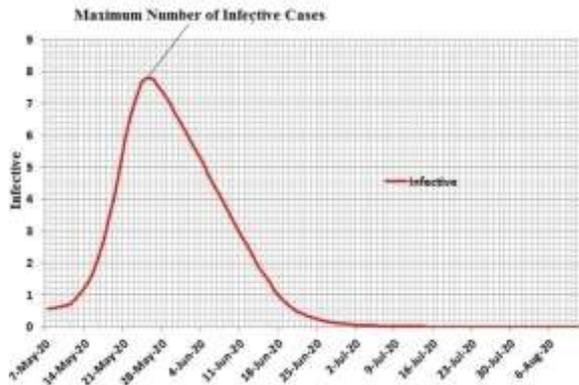


Figure 4: Maximum Number of Infective cases

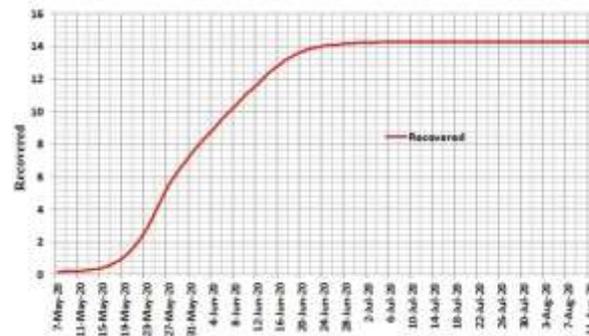


Figure 5: Recovered cases of COVI-2019 outbreak

4. Conclusion

Based on the data as of 9 May 2020 in the study presented, the SIR model indicates that COVID-2019 outbreak will be at its peak in India by 25 May 2020 or by the end of May. On the basis of this study, we can say that after the end of May 2020, the outbreak of this epidemic will start working slowly and by the first week of August 2020, the outbreak of this epidemic will be towards end. On the basis of the data obtained by this model, it would be wrong to say that the COVID-2019 outbreak in India will go on because people here today are neither following social distancing nor applying their face masks. Hence this epidemic threat is very high risk in India. This study also shows that if locking, social distancing and masks etc. are used properly in India, then the outbreak of COVID-2019 epidemic can be almost eliminated in the first or second week of August 2020. This proposed SIR model will automatically estimates the number of cases of weekly, bi-weekly, month and even year. Therefore, we can say that the Indian government and doctors can maintain a check on hospital facilities, necessary supplies for new patients, medical aid and isolation for next week or in future.

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Table 1: SIR Methods Simulation and Results of Runge Kutta Fourth Order Method

S.No.	Date	Day/Time	S	I	R	S+I+R
1	7-May-2020	0	13.57410	0.56340	0.18430	14.32180
2	8-May-2020	0.1407	13.53930	0.59240	0.19010	14.32180
3	9-May-2020	0.2815	13.50290	0.62280	0.19620	14.32190
4	10-May-2020	0.4222	13.46460	0.65460	0.20260	14.32180
5	11-May-2020	0.5629	13.42450	0.68790	0.20930	14.32170
6	12-May-2020	1.2091	13.21490	0.86190	0.24500	14.32180
7	13-May-2020	1.8552	12.95740	1.07490	0.28950	14.32180
8	14-May-2020	2.5013	12.64410	1.33280	0.34490	14.32180
9	15-May-2020	3.1474	12.26760	1.64090	0.41330	14.32180
10	16-May-2020	3.99	11.67150	2.12430	0.52600	14.32180
11	17-May-2020	4.8326	10.94780	2.70320	0.67090	14.32190
12	18-May-2020	5.6752	10.09940	3.36910	0.85330	14.32180
13	19-May-2020	6.5178	9.14520	4.09880	1.07780	14.32180
14	20-May-2020	7.5519	7.87820	5.02850	1.41510	14.32180
15	21-May-2020	8.586	6.58980	5.91230	1.81970	14.32180
16	22-May-2020	9.6202	5.36510	6.67150	2.28520	14.32180
17	23-May-2020	10.6543	4.27120	7.24990	2.80070	14.32180
18	24-May-2020	11.8923	3.19080	7.66910	3.46190	14.32180
19	25-May-2020	13.1304	2.35370	7.82000	4.14810	14.32180
20	26-May-2020	14.3684	1.72990	7.75340	4.83860	14.32190
21	27-May-2020	15.6065	1.28090	7.52520	5.51570	14.32180
22	28-May-2020	16.5352	1.03080	7.28400	6.00700	14.32180
23	29-May-2020	17.4639	0.83580	7.00500	6.48100	14.32180
24	30-May-2020	18.3926	0.68320	6.70270	6.93590	14.32180
25	31-May-2020	19.3213	0.56360	6.38800	7.37030	14.32190
26	1-June-2020	20.2499	0.46950	6.06890	7.78340	14.32180
27	2-June-2020	21.1786	0.39480	5.75160	8.17540	14.32180
28	3-June-2020	22.1073	0.33510	5.44010	8.54660	14.32180
29	4-June-2020	23.036	0.28690	5.13750	8.89740	14.32180
30	5-June-2020	24.1739	0.24010	4.78130	9.30040	14.32180
31	6-June-2020	25.3118	0.20350	4.44320	9.67510	14.32180
32	7-June-2020	26.4497	0.17450	4.12410	10.02320	14.32180
33	8-June-2020	27.5876	0.15130	3.82440	10.34610	14.32180
34	9-June-2020	29.0546	0.12780	3.46620	10.72780	14.32180
35	10-June-2020	30.5215	0.10970	3.13850	11.07360	14.32180
36	11-June-2020	31.9885	0.09550	2.83970	11.38660	14.32180
37	12-June-2020	33.4554	0.08430	2.56780	11.66970	14.32180
38	13-June-2020	35.604	0.07170	2.21410	12.03600	14.32180
39	14-June-2020	37.7526	0.06240	1.90760	12.35180	14.32180

40	15-June-2020	39.9012	0.05540	1.64270	12.62370	14.32180
41	16-June-2020	42.0498	0.05000	1.41410	12.85780	14.32190
42	17-June-2020	45.092	0.04420	1.14270	13.13500	14.32190
43	18-June-2020	48.1343	0.04000	0.92290	13.35890	14.32180
44	19-June-2020	51.1766	0.03700	0.74560	13.53910	14.32170
45	20-June-2020	54.2188	0.03480	0.60240	13.68470	14.32190
46	21-June-2020	57.0367	0.03310	0.49390	13.79480	14.32180
47	22-June-2020	59.8547	0.03180	0.40500	13.88500	14.32180
48	23-June-2020	62.6726	0.03080	0.33210	13.95890	14.32180
49	24-June-2020	65.4905	0.03000	0.27240	14.01940	14.32180
50	25-June-2020	68.2881	0.02940	0.22360	14.06880	14.32180
51	26-June-2020	71.0857	0.02880	0.18350	14.10940	14.32170
52	27-June-2020	73.8833	0.02840	0.15070	14.14270	14.32180
53	28-June-2020	76.6809	0.02810	0.12380	14.17000	14.32190
54	29-June-2020	79.4708	0.02780	0.10160	14.19240	14.32180
55	30-June-2020	82.2608	0.02760	0.08350	14.21080	14.32190
56	1-July-2020	85.0508	0.02740	0.06860	14.22590	14.32190
57	2-July-2020	87.8408	0.02720	0.05630	14.23820	14.32170
58	3-July-2020	90.6279	0.02710	0.04630	14.24840	14.32180
59	4-July-2020	93.415	0.02700	0.03800	14.25680	14.32180
60	5-July-2020	96.2022	0.02690	0.03120	14.26360	14.32170
61	6-July-2020	98.9893	0.02690	0.02570	14.26930	14.32190
62	7-July-2020	101.775	0.02680	0.02110	14.27390	14.32180
63	8-July-2020	104.561	0.02680	0.01730	14.27770	14.32180
64	9-July-2020	107.347	0.02670	0.01420	14.28090	14.32180
65	10-July-2020	110.133	0.02670	0.01170	14.28340	14.32180
66	11-July-2020	112.918	0.02670	0.00960	14.28550	14.32180
67	12-July-2020	115.704	0.02670	0.00790	14.28730	14.32190
68	13-July-2020	118.489	0.02660	0.00650	14.28870	14.32180
69	14-July-2020	121.275	0.02660	0.00530	14.28990	14.32180
70	15-July-2020	124.06	0.02660	0.00440	14.29080	14.32180
71	16-July-2020	126.845	0.02660	0.00360	14.29160	14.32180
72	17-July-2020	129.63	0.02660	0.00300	14.29230	14.32190
73	18-July-2020	132.415	0.02660	0.00240	14.29280	14.32180
74	19-July-2020	135.2	0.02660	0.00200	14.29320	14.32180
75	20-July-2020	137.985	0.02660	0.00160	14.29360	14.32180
76	21-July-2020	140.77	0.02660	0.00130	14.29390	14.32180
77	22-July-2020	143.555	0.02660	0.00110	14.29410	14.32180
78	23-July-2020	146.34	0.02660	0.00090	14.29430	14.32180
79	24-July-2020	149.125	0.02660	0.00070	14.29450	14.32180
80	25-July-2020	151.91	0.02660	0.00060	14.29460	14.32180
81	26-July-2020	154.695	0.02660	0.00050	14.29470	14.32180
82	27-July-2020	157.48	0.02660	0.00040	14.29480	14.32180
83	28-July-2020	160.265	0.02660	0.00030	14.29490	14.32180
84	29-July-2020	163.05	0.02660	0.00030	14.29500	14.32190
85	30-July-2020	165.835	0.02660	0.00020	14.29500	14.32180
86	31-July-2020	169.03	0.02660	0.00020	14.29510	14.32190
87	1-August-2020	172.225	0.02660	0.00010	14.29510	14.32180
88	2-August-2020	175.42	0.02660	0.00010	14.29510	14.32180
89	3-August-2020	178.615	0.02660	0.00010	14.29510	14.32180
90	4-August-2020	182.323	0.02660	0.00010	14.29520	14.32190
91	5-August-2020	186.031	0.02660	0.00010	14.29520	14.32190
92	6-August-2020	189.739	0.02660	0.00000	14.29520	14.32180
93	7-August-2020	193.448	0.02660	0.00000	14.29520	14.32180

94	8-August-2020	195.086	0.02660	0.00000	14.29520	14.32180
95	9-August-2020	196.724	0.02660	0.00000	14.29520	14.32180
96	10-August-2020	198.362	0.02660	0.00000	14.29520	14.32180
97	11-August-2020	200.000	0.02660	0.00000	14.29520	14.32180