COVID-19 USING NUMERICAL METHOD

A DISSERTATION

SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS

FOR THE AWARD OF THE DEGREE
OF

MASTER OF SCIENCE
IN
MATHEMATICS

SUBMITTED BY:

Pradeep Kumar
(2K19/MSCMAT/27)

UNDER THE SUPERVISION OF

Prof. Vivek Kumar Aggarwal

DEPARTMENT OF APPLIED MATHEMATICS

DELHI TECHNOLOGICAL UNIVERSITY
(Formerly Delhi College of Engineering)
Bawana Road, Delhi – 110042

May-2021

Delhi Technological University
(Formerly Delhi College of Engineering)
Bawana Road, Delhi-110042

CANDIDATE'S DECLARATION

I PRADEEP KUMAR, Roll No. 2K19/MSCMAT/27 **of** Master of science in mathematics, hereby declare that the project Dissertation titled "COVID-19 USING NUMERICAL METHOD" which is submitted by me to the Department of Applied Mathematics**,** Delhi Technological University, Delhi in partial fulfillment of the requirement for the award of the degree of Master of science, is original and not copied from any source without proper citation. This work has not previously formed the basis for the award of any degree, diploma associateship or other similar title or recognition.

Place: Delhi PRADEEP KUMAR

Date: 06/05/2021

Pradeep kumar

Department of Mathematics
Delhi Technological University
(Formerly Delhi College of Engineering)
Bawana Road, Delhi-110042

CERTIFICATE

I hereby certify that the dissertation report "COVID-19 USING NUMERICAL METHOD" Which is submitted by PRADEEP KUMAR, Roll No. 2K19/MSCMAT/27 Department of Applied mathematics, Delhi Technological University, Delhi for the partial fulfillment of the requirement for the award of the degree of Master of science is record of the project work carried out by the student under my supervision. To the best of my knowledge this work has not been submitted in part or full for any degree or diploma to this university or elsewhere.

Place: Delhi **Prof. Vivek kumar Aggarwal**

Date: 06/05/2021 SUPERVISOR

ACKNOWLEDGEMENT

I want to like express my sincere thank to Prof. S. SIVAPRASAD KUMAR, Head, Department of Applied Mathematics for his kind hearted support. I also wish to express my gratitude of my teachers for giving me this opportunity to undertake this project. I am also grateful to
my instructors for their consistent help and direction.

It gives me colossal joy to communicate my most profound feeling of appreciation and sincere thanks to my highly respected and esteemed guide Prof. Vivek Kumar Aggarwal for his valuable guidance, encouragement and help for completing this work. His useful suggestion for this whole work and co-operative behaviour are sincerely acknowledged.

I also extend thanks to all other faculty and non- teaching staff of Department of Mathematics for their external support and guidance.

PRADEEP KUMAR

M.SC MATHEMATICS, IV SEM

DTU, NEW DELHI

Pradeepkumar

Abstract

The SIR model is used to discuss the spread of the covid-19 epidemic in the Indian state of Maharashtra and its eventual end. Here we have examined about the spread of Coronavirus pandemic in extraordinary profundity utilizing Runge-kutta fourth-order method. The Runge-kutta fourth-order method is a solving of the non-linear ordinary differential. We have used the data of covid-19 Outbreak of state Maharashtra on 29 April, 2021. The total population of Maharashtra is 122153000, according to this data. For the initial stage of experimental purposes, we used 113814181 susceptible cases, 4539553 infectious cases, and 3799266 recovered cases. The SIR model was used to analyse data from a wide range of infectious diseases. As a result, several scientists and researchers have thoroughly tested this model for infectious diseases. As a result of the research and simulation of this proposed covid-19 model using data on the number of covid-19 outbreak cases in state Maharashtra of India, show that the covid-19 epidemic infection cases rise for a period of time after the outbreak decreases, and then the covid-19 outbreak ends in Maharashtra cases. The model's findings also show that the Runge-kutta fourth-order method is used for forecast and avoid the covid-19 outbreak in India's Maharashtra state. Finally, we determine that the outbreak of the covid-19 epidemic in Maharashtra will peak on 11 May 2021, after which it will progress steadily and will likely end in the fourth week of October 2021.

Keywords- covid-19, Data set of Maharashtra state of India, SIR model, Runge-kutta fourth-order method.

TABLE OF CONTENT

List of Figures

CHAPTER 1

INTRODUCTION

Today, The corona virus outbreak has emerged as a major challenge for India. Covid-19 has about 18755183 confirmed cases and 15374052 recovered cases of 29 April, 2021. Almost population of the India and world is now using lockdown, social distancing and masks to stop this. At the moment, India and all states are using certain tools to combat the covid-19 epidemic. The covid-19 outbreak is a member of SARS-Cov-2. India medicine was created by the Indian Serum Institute and Bharat Biotech. Vaccine name is covishield and covaxin. India began its vaccination program from 16 January2021. Covid-2019 is an epidemic that spreads quickly from one person to another through infected person's breathing or touch.

As a result, covid-2019 is a communicable disease. This disease has a 2 to 14-day incubation period. According to a new survey, the covid-19 epidemic is estimated to be around. This infection deadly for individuals over 60 years and more fatal those people who have already suffered from a major disease such as cancer, tuberculosis etcetera. On April 29, 2021, a patient with Covid-19 was discovered in Kerala, India. This individual arrived in Kerala state of India from Wuhan, China. The primary instance of Coronavirus was found in China's Wuhan city at the end of November 2019. After 30 January 2020, the covid-19 virus began to spread in India and has now spread throughout the world.

India's Prime Minister, Narendra Modi, declared the Janata curfew for March 22, 2020 on March 19, 2020. After this, India's Prime Minister declared a countrywide lockdown for 21 days on March 24, 2020 though an investigation has recommended that this period might be lacking for controlling the Coronavirus pandemic offered lockdown in all over India from 25 march to till 14 April 2020 we called a phase l. Even after 14 April lockdown again government of india offered lockdown to all over india from 15 April to till 3 may 2020 (19 days) The number of covid-19 epidemic patients in India has risen so government of india apply lockdown Phase 3 and Phase 4 till 31 may 2020.

Now Maharashtra government announced lockdown date from 12 April 2021 to 30 April 2021 and now day government extend lockdown for 15 days. Today, the Covid-19 outbreak data in India, which was made available by the Ministry of Health and Family Welfare, covid-19 India and my government website, 18755183are infected (confirmed), were 15374052 recovered and 208314 people died on 29 April 2021. Similar Maharashtra data initial data is 4539553 are infected (confirmed), 3799266 were recovered (cured) and 67985 people died on 29 April 2021. However, India has a much higher population density than other nations, and medical services are scarce. As a result, the chance of corona virus transmission in this area is extremely high. Despite this, Maharashtra has a high rate of corona infection as compared to other states. According to recent studies, the cause of corona virus infection in Maharashtra is due to population. All of these findings are observational, and no scientific evidence of this form of research has been found to date. Hence there is a need to examine Coronavirus outbreak with more proof at this point. In this report, we presented an epidemic model of covid-19 outbreak in Maharashtra. We have likewise viewed as the impacts of social separating on infection formation, lockdown, and face masking in this proposed analysis. From the time of the spread to India, we presumed the empacts of social distancing steps, lockout, and face cover in Maharashtra.

The objectives of these studies are given below:

1. Find the maximum Infected population of covid-19 in Maharashtra.
2. Finding the rate of spread of the covid-19 in Maharashtra.
3. Find the end stage of covid-19 in Maharashtra.

CHAPTER 2

Modelling of covid-19 disease

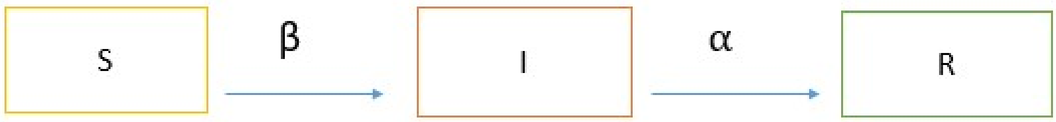
In this proposed analysis, we considered an outbreak model created by Kermack and McKendrick in 1991. This epidemic model is also known as SIR (Susceptible, Infective, and Recover). it have already successfully used in Many infectious outbreaks such as avian influenza, cholera, SARS, Aids, Plague, Yellow Fever, Zika , Rift Valley Fever, Lassa Fever, Leptospirosis. This SIR model is extremely useful for forecasting future events, such as the height of infectious disease activity and recovered cases.

This project work aims to use SIR model for covid-19 and quantify the prevalence of covid-19 in Maharashtra, where the virus spreads more quickly and causes disastrous outcomes. Model assumption

- No birth in covid-19 model and also no death include in this model.
- The population size is fixed (NO one enters or leaves the population throughout the duration of the disease) i.e no birth, death due to other disease or natural death.
- The population is well mixed (All individual have an equally likely chance of being infected).

1. S: number of susceptible of covid-19 population in Maharashtra.
2. I: the number of infected (is known as confirmed) of covid-19 population in Maharashtra.
3. R: Number of recovered (is known as cured) of covid-19 population in Maharashtra.

The flow diagram of our model represent by given below the classification which divide the population into three compartments for Covid-19 is Susceptible (S), Infected (I) and Removed (R). In Figure (a).



(a) Covid-19 Model

Let us find the following three non-linear differential conditions being utilized for Maharashtra of Indian covid-19 experimental studies and experimental debate. The definition is given below for these three differential equations:

$$S'(t) = -\beta * S * I \qquad (2.1)$$

$$I'(t) = \beta * S * I - \alpha * I \qquad (2.2)$$

$$R'(t) = \alpha * I \qquad (2.3)$$

Where,

- $S(t)$ is susceptible
- $I(t)$ is infected of covid-19 population.
- $R(t)$ is recovered population.
- β is a rate of susceptible of covid-19 population convert into infected of covid-19 population.
- α is a rate of infected of covid-19 population removed into recovered of covid-19 population.
- $S + I + R = N$, Where N = total population of covid-19

The system of differential equations are known as covid-19 in Maharashtra state of India. The average outbreak time for covid-19 in Maharashtra is about 14 days, according to the proposed report. In the early stages of resolving Maharashtra's three differential covid-19 outbreak equations, these numerical β and α values are extremely useful.

At all covid-19 outbreak rates, the population remains stable. The expression above can also be denoted in the following form:

$$S(t) + I(t) + R(t) = N \qquad (2.4)$$

We will utilized initial values condition for the Covid-19 model, i.e., for the experimental reason of data analysis of the covid-19 epidemic of Maharashtra

$S(0) = S0$, $I(t) = I0$, and $R(0) = R0$

2.1 SPREAD RATE OF COVID-19

The estimated number of cases directly generated by one case in a population where all individuals are susceptible to infection is known as the basic reproduction number or spread rate (Rn) of an infection. The basic reproduction number for Covid-19 model can be derived based on multiple methods. Here, we illustrate the method that depends on the eigenvalues of the Jacobian of the differential equation of the SIR model.

Write the Jacobian matrix from equation 1, 2 and 3

$$J(S,I,R)=\begin{bmatrix} -\beta^*I & -\beta^*S & 0 \\ \beta^*I & \beta^*S-\alpha^*I & 0 \\ 0 & \alpha & 0 \end{bmatrix}$$

Now, equilibrium of the model is (S_0, 0, 0), We have calculated the Jacobian matrix

$$J_0 \quad = \begin{bmatrix} 0 & -\beta^*S_0 & 0 \\ 0 & \beta^*S_0-\alpha & 0 \\ 0 & \alpha & 0 \end{bmatrix}$$

To find out the eigenvalues of the Jacobian matrix, we have put the
21

$$\det(J_0 - \lambda I) = 0$$

Then the characteristics polynomial of matrix

$$\lambda^3 - \lambda^2 \beta^*S_0 + \lambda^2 \alpha = 0$$

$$\lambda^2 (- \beta^*S_0 + \alpha) = 0$$

The root of polynomial

λ_1 , λ_2 = 0 and $\lambda_3 = \beta^*S_0-\alpha$

Then $\lambda_3 = \beta^*S_0-\alpha$

$$= \alpha \left(\frac{\beta S_0}{\alpha} - 1 \right)$$

Model is stable then $\lambda_3 < 0$ and unstable when $\lambda_3 > 0$

$\lambda_3 = \alpha (R_n - 1)$ where $R_n = \frac{(\beta^*S_0)}{(\alpha)}$

As we know that model is stable $\lambda_3 < 0$

Case (1) $\lambda_3 = \beta^*S_0-\alpha < 0 \Rightarrow \alpha \left(\frac{\beta S_0}{\alpha} - 1 \right) < 0$. It means $\lambda_3 < 0$ then $\frac{\beta S_0}{\alpha} < 1$. i.e. $R_n < 1$

Case (2) $\lambda_3 > 0$ then $\frac{\beta S_0}{\alpha} > 1$. i.e. $R_n > 1$

These model of covid-19 outbreak behaviour is determined by the values of the following expressions.

$$R_n = \frac{(\beta^*S_0)}{(\alpha)} \qquad (2.5)$$

Finally we conclude that if R_n is less than one then covid-19 epidemic will be does out from Maharashtra. If R_n is greater than one, then the outbreak of covid-19 is still in epidemic form in Maharashtra.

2.2 Maximum number of infected people

The system of differential equations with three unknowns. Such differential equation schemes are extremely difficult to solve. After solve equations (1) and (2), we obtain a single differential equation with an unknown of this model. In order to find out the maximum infected people. We have solved first two differential equation of model.

According to the chain rule
It means

$$\frac{dI}{dS} = \frac{dI/dt}{dS/dt} = \frac{\beta * S * I - \alpha * I}{-\beta * S * I} = \frac{\beta * S * I}{-\beta * S * I} - \frac{-\alpha * I}{-\beta * S * I}$$

$$= \frac{\alpha}{\beta * S} - 1$$

$$dI = \left(\frac{\alpha}{\beta * S} - 1\right) dS$$

Integrating both side

$$\int dI = \int \left(\frac{\alpha}{\beta * S} - 1\right) dS$$

$$I = \frac{\alpha}{\beta} \ln(S) - S + C \qquad (2.6)$$

Where, C is arbitrary constant

$$R = N - I - S$$

SIR model is equal equipped with the initial condition

$S = S_0$ and $I = I_0$

$$I_0 = \frac{\alpha}{\beta} \ln(S_0) - S_0 + C$$

$$C = I_0 + S_0 - \frac{\alpha}{\beta} \ln(S_0)$$

Using equation (6)

$I = \frac{\alpha}{\beta} \ln(S) - S + C$

$l\, I\, l \leq l\ \frac{\alpha}{\beta}\ \ln(S) - S\ \ l + l\, C\, l$ (2.7)

Now, we apply Theorem maxima and minima.

Take

$F(S) = \frac{\alpha}{\beta}\ \ln(S) - S$

We know that function is maximum if let find a F''(S) < 0 and dF'(S) = 0.
So by function F(S)

$F'(S) = \frac{\alpha}{\beta * S} - 1 = 0\ S^2$

$S = \frac{\alpha}{\beta}$

$F''(S) = \frac{-\alpha}{\beta * S^2} < 0$

Put the value of S in F''(S) then

$S = \frac{\alpha}{\beta} \Rightarrow l\ \frac{\alpha}{\beta}\ \ln(S) - S\ l$ is maximum

F''(S) is less than zero. It means F''(S) is maximum.

Put the value of S in equation (7)

$I_{max} = \frac{\alpha}{\beta} \ln(\frac{\alpha}{\beta}) - \frac{\alpha}{\beta} + l\, C\, l$ (2.8)

Where, I_{max} is maximum number of infected cases from covid-19 in Maharashtra.

Put the value of C in equation (8)

$I_{max} = \frac{\alpha}{\beta} \ln(\frac{\alpha}{\beta}) - \frac{\alpha}{\beta} + I_0 + S_0 - \frac{\alpha}{\beta} \ln(S_0)$ (2.9)

The above equation is maximum number of infected.

CHAPTER 3

Method for solving the covid-19 model

We have various type of method to solve the system such as euler method, Runge-Kutta fourth order. Runge-Kutta fourth is better as compare to euler because order of one of euler method and order of Runge-Kutta fourth methed is four. Accuracy, stability, and can be easily programmed level of Runge-Kutta fourth methed.

So that we have taken Runge-Kutta fourth order for solving the model. The step of Runge-Kutta fourth order to solve the model are discuss below.

3.1 Runge-Kutta fourth order

Let an initial value problem be specified as follows:

$$\frac{dy}{dx} = f(t,y) \qquad y(t_0) = y_0$$

Here y is an unknown function (scalar or vector) of time t, which we would like to approximate; we are told that $\frac{dy}{dx}$, the rate at which y changes, is a function of t and of y itself. At the initial time t_0 the corresponding y value is y_0. The function f and the initial conditions t_0, y_0 are given.

we have used Runge-Kutta fourth order for solving covid-19 model based differential equation. we used the MATLAB programme to solve the differential equation using initial conditions.

The 4th order Runge-Kutta method for a non-linear differential equations has the following

$$\frac{dS}{dt} = f(t, S, I, R) = -\beta S_n I_n$$

$$\frac{dI}{dt} = f(t, S, I, R) = \beta S_n I_n - \alpha I_n$$

$$\frac{dR}{dt} = f(t, S, I, R) = \alpha I_n$$

Where $f(t_n,y_n)$ is the slope of the curve and is a small phase size in the time domain. Here, we want to measure the dependent variables called S, I and R to the proposed SIR model. Therefore the solution of proposed SIR model based differential is transformed into Runge-Kutta fourth order method forms which are given below:

$$S_{n+1} = S_n + \frac{\Delta t}{6}\left(K_1^S + 2K_2^S + 2\,K_3^S + K_4^S \right) \qquad (3.1)$$

$$K_1^S = f(t_n, S_n, I_n) = -\beta S_n I_n$$

$$K_2^S = f\left(t_n + \frac{\Delta t}{2}, S_n + \frac{K_1^S\ \Delta t}{2}, I_n + \frac{K_1^I\ \Delta t}{2}\right) = -\beta\left(S_n + \frac{K_1^S\ \Delta t}{2}\right)\left(I_n + \frac{K_1^I\ \Delta t}{2}\right)$$

$$K_3^S = f\left(t_n + \frac{\Delta t}{2}, S_n + \frac{K_2^S\ \Delta t}{2}, I_n + \frac{K_2^I\ \Delta t}{2}\right) = -\beta\left(S_n + \frac{K_2^S\ \Delta t}{2}\right)\left(I_n + \frac{K_2^I\ \Delta t}{2}\right)$$

$$K_4^S = f\left(t_n + \frac{\Delta t}{2}, S_n + \frac{K_3^S\ \Delta t}{2}, I_n + \frac{K_3^I\ \Delta t}{2}\right) = -\beta\left(S_n + \frac{K_3^S\ \Delta t}{2}\right)\left(I_n + \frac{K_3^I\ \Delta t}{2}\right)$$

$$I_{n+1} = I_n + \frac{\Delta t}{6}\left(K_1^I + 2K_2^I + 2\,K_3^I + K_4^I \right) \qquad (3.2)$$

$$K_1^I = f(t_n, S_n, I_n) = \beta S_n I_n - \alpha I_n$$

$$K_2^I = f\left(t_n + \frac{\Delta t}{2}, S_n + \frac{K_1^S\ \Delta t}{2}, I_n + \frac{K_1^I\ \Delta t}{2}\right) = \beta\left(S_n + \frac{K_1^S\ \Delta t}{2}\right)\left(I_n + \frac{K_1^I\ \Delta t}{2}\right) - \alpha\left(I_n + \frac{K_1^I\ \Delta t}{2}\right)$$

$$K_3^I = f\left(t_n + \frac{\Delta t}{2}, S_n + \frac{K_2^S\ \Delta t}{2}, I_n + \frac{K_2^I\ \Delta t}{2}\right) = \beta\left(S_n + \frac{K_2^S\ \Delta t}{2}\right)\left(I_n + \frac{K_2^I\ \Delta t}{2}\right) - \alpha\left(I_n + \frac{K_2^I\ \Delta t}{2}\right)$$

$$K_4^I = f\left(t_n + \frac{\Delta t}{2}, S_n + \frac{K_3^S\ \Delta t}{2}, I_n + \frac{K_3^I\ \Delta t}{2}\right) = \beta\left(S_n + \frac{K_3^S\ \Delta t}{2}\right)\left(I_n + \frac{K_3^I\ \Delta t}{2}\right) - \alpha\left(I_n + \frac{K_3^I\ \Delta t}{2}\right)$$

$$R_{n+1} = R_n + \frac{\Delta t}{6}\left(K_1^R + 2K_2^R + 2\,K_3^R + K_4^R \right) \qquad (3.3)$$

$$K_1^R = f(t_n, I_n) = \alpha I_n$$

$$K_2^R = f\left(t_n + \frac{\Delta t}{2}, I_n + \frac{K_1^I\ \Delta t}{2}\right) = \alpha\left(I_n + \frac{K_1^I\ \Delta t}{2}\right)$$

$$K_3^R = f\left(t_n + \frac{\Delta t}{2}, I_n + \frac{K_2^I\ \Delta t}{2}\right) = \alpha\left(I_n + \frac{K_2^I\ \Delta t}{2}\right)$$

$$K_4^R = f\left(t_n + \frac{\Delta t}{2}, I_n + \frac{K_3^I\ \Delta t}{2}\right) = \alpha\left(I_n + \frac{K_3^I\ \Delta t}{2}\right)$$

Applying the 4th order Runge-Kutta method, initial conditions are required. The data obtained from covid-19 India and my government website (29 April 2021 to 13 November 2021). Taking the total population of Maharashtra as N=12.2153000,

S_0=11.3814181, I_0=0.4539553, R_0=0.3799266.

The following expression can be used to measure the value of the covid-19 recovered rate and covid-19 infection rate of Maharashtra's covid-19 outbreak:

$$\beta = \frac{\text{Infected population of Maharashtra on 29 April 2021}}{\text{Susceptible population of Maharashtra on 29 April 2021}}$$

$$\beta = \frac{0.4539553}{11.3814181}$$

$$\beta = 0.0398856$$

$$\alpha = 1/14 = 0.0714$$

$$\Delta t = 1$$

Using the values of β, α, S_0, I_0, R_0 andΔt in condition (3.1), (3.2) and (3.3) to get the next generation values S_1, I_1 and R_1 can be obtained. Similarly, we can assess other iterations in the same way. The numerical results of Runge-kutta fourth-order method of covid-19 model.

3.2 Covid-19 model Simulation

The Covid-19 model related in Matlab 2012 b envolvement. The inbuilt function ode45 solver was used this solver is based on Runge-Kutta fourth order.

On solving the covid-19 model. we have obtained the solution and numerical values of solution it present in table.

Table: Covid-19 model Simulation using Runge- Kutta Fourth Order Method

Dates	Susceptible	Infected	recovered
29/04/2021	11.3814	0.4540	0.3799
30/04/2021	11.1336	0.6624	0.4193
01/05/2021	10.7835	0.9553	0.4765
01/05/2021	10.3019	1.3551	0.5583
02/05/2021	9.6629	1.8794	0.6729
03/05/2021	8.8516	2.5338	0.8298
04/05/2021	7.8817	3.2962	1.0374
05/05/2021	6.7979	4.1154	1.3020
06/05/2021	5.6778	4.9128	1.6246
07/05/2021	4.6018	5.6125	2.0011
08/05/2021	3.6360	6.1569	2.4223
09/05/2021	2.8251	6.5149	2.8753
10/05/2021	2.1687	6.6993	3.3473
11/05/2021	1.6532	6.7344	3.8277
12/05/2021	1.2607	6.6479	4.3068
13/05/2021	0.9689	6.4704	4.7761
14/05/2021	0.7518	6.2337	5.2297
15/05/2021	0.5893	5.9608	5.6652
16/05/2021	0.4669	5.6678	6.0806

17/05/2021	0.3746	5.3661	6.4745
18/05/2021	0.3043	5.0642	6.8468
19/05/2021	0.2501	4.7674	7.1978
20/05/2021	0.2080	4.4795	7.5279
21/05/2021	0.1749	4.2027	7.8377
22/05/2021	0.1487	3.9383	8.1283
23/05/2021	0.1277	3.6871	8.4005
24/05/2021	0.1108	3.4494	8.6552
25/05/2021	0.0970	3.2250	8.8933
26/05/2021	0.0856	3.0137	9.1160
27/05/2021	0.0762	2.8151	9.3240
28/05/2021	0.0684	2.6286	9.5183
29/05/2021	0.0618	2.4538	9.6997
30/05/2021	0.0562	2.2901	9.8690
31/05/2021	0.0515	2.1369	10.0270
01/06/2021	0.0474	1.9935	10.1744
02/06/2021	0.0439	1.8595	10.3119
03/06/2021	0.0409	1.7343	10.4401
04/06/2021	0.0383	1.6174	10.5597
05/06/2021	0.0359	1.5081	10.6712
06/06/2021	0.0339	1.4061	10.7753
07/06/2021	0.0321	1.3108	10.8724
08/06/2021	0.0305	1.2219	10.9629
09/06/2021	0.0291	1.1390	11.0472
10/06/2021	0.0279	1.0616	11.1258
11/06/2021	0.0268	0.9896	11.1990
12/06/2021	0.0258	0.9224	11.2671
13/06/2021	0.0249	0.8598	11.3306
14/06/2021	0.0242	0.8014	11.3898
15/06/2021	0.0234	0.7470	11.4449
16/06/2021	0.0228	0.6961	11.4964
17/06/2021	0.0222	0.6487	11.5444
18/06/2021	0.0216	0.6045	11.5892
19/06/2021	0.0211	0.5632	11.6310
20/06/2021	0.0207	0.5248	11.6698
21/06/2021	0.0203	0.4890	11.7060
22/06/2021	0.0199	0.4557	11.7397
23/06/2021	0.0195	0.4246	11.7711
24/06/2021	0.0192	0.3957	11.8003
25/06/2021	0.0189	0.3688	11.8275
26/06/2021	0.0187	0.3437	11.8529

27/06/2021	0.0184	0.3203	11.8766
28/06/2021	0.0182	0.2984	11.8987
29/06/2021	0.0180	0.2780	11.9193
30/06/2021	0.0178	0.2590	11.9385
01/07/2021	0.0176	0.2413	11.9563
02/07/2021	0.0175	0.2248	11.9730
03/07/2021	0.0173	0.2095	11.9885
04/07/2021	0.0172	0.1952	12.0029
05/07/2021	0.0170	0.1819	12.0164
06/07/2021	0.0169	0.1695	12.0289
07/07/2021	0.0168	0.1580	12.0405
08/07/2021	0.0167	0.1472	12.0514
09/07/2021	0.0166	0.1371	12.0615
10/07/2021	0.0165	0.1278	12.0710
11/07/2021	0.0165	0.1190	12.0798
12/07/2021	0.0164	0.1109	12.0880
13/07/2021	0.0163	0.1033	12.0957
14/07/2021	0.0162	0.0962	12.1028
15/07/2021	0.0162	0.0897	12.1094
16/07/2021	0.0161	0.0836	12.1156
17/07/2021	0.0161	0.0779	12.1214
18/07/2021	0.0160	0.0726	12.1267
19/07/2021	0.0160	0.0676	12.1317
20/07/2021	0.0159	0.0630	12.1364
21/07/2021	0.0159	0.0587	12.1407
22/07/2021	0.0159	0.0547	12.1448
23/07/2021	0.0158	0.0509	12.1485
24/07/2021	0.0158	0.0474	12.1521
25/07/2021	0.0158	0.0442	12.1553
26/07/2021	0.0157	0.0412	12.1584
27/07/2021	0.0157	0.0384	12.1612
28/07/2021	0.0157	0.0358	12.1638
29/07/2021	0.0157	0.0333	12.1663
30/07/2021	0.0157	0.0310	12.1686
31/07/2021	0.0156	0.0289	12.1707
01/08/2021	0.0156	0.0269	12.1727
02/08/2021	0.0156	0.0251	12.1746
03/08/2021	0.0156	0.0234	12.1763
04/08/2021	0.0156	0.0218	12.1779
05/08/2021	0.0156	0.0203	12.1794
06/08/2021	0.0156	0.0189	12.1808

07/08/2021	0.0155	0.0176	12.1821
08/08/2021	0.0155	0.0164	12.1834
09/08/2021	0.0155	0.0153	12.1845
10/08/2021	0.0155	0.0143	12.1855
11/08/2021	0.0155	0.0133	12.1865
12/08/2021	0.0155	0.0124	12.1874
13/08/2021	0.0155	0.0115	12.1883
14/08/2021	0.0155	0.0107	12.1891
15/08/2021	0.0155	0.0100	12.1898
16/08/2021	0.0155	0.0093	12.1905
17/08/2021	0.0155	0.0087	12.1912
18/08/2021	0.0155	0.0081	12.1918
19/08/2021	0.0155	0.0075	12.1923
20/08/2021	0.0155	0.0070	12.1928
21/08/2021	0.0155	0.0065	12.1933
22/08/2021	0.0155	0.0057	12.1938
23/08/2021	0.0155	0.0053	12.1942
24/08/2021	0.0155	0.0049	12.1946
25/08/2021	0.0155	0.0046	12.1949
26/08/2021	0.0155	0.0043	12.1953
27/08/2021	0.0155	0.0040	12.1956
28/08/2021	0.0155	0.0037	12.1959
29/08/2021	0.0155	0.0035	12.1962
30/08/2021	0.0155	0.0032	12.1964
31/08/2021	0.0155	0.0030	12.1967
01/09/2021	0.0155	0.0028	12.1969
02/09/2021	0.0155	0.0026	12.1971
03/09/2021	0.0155	0.0024	12.1973
04/09/2021	0.0155	0.0023	12.1975
05/09/2021	0.0155	0.0021	12.1976
06/09/2021	0.0155	0.0020	12.1978
07/09/2021	0.0155	0.0018	12.1979
08/09/2021	0.0155	0.0017	12.1981
09/09/2021	0.0155	0.0016	12.1982
10/09/2021	0.0155	0.0015	12.1983
11/09/2021	0.0155	0.0014	12.1984
12/09/2021	0.0155	0.0013	12.1985
13/09/2021	0.0155	0.0012	12.1986
14/09/2021	0.0155	0.0011	12.1987
15/09/2021	0.0155	0.0010	12.1988
16/09/2021	0.0155	0.0010	12.1989

17/09/2021	0.0155	0.0009	12.1990
18/09/2021	0.0155	0.0008	12.1991
19/09/2021	0.0155	0.0008	12.1991
20/09/2021	0.0155	0.0007	12.1992
21/09/2021	0.0155	0.0007	12.1992
22/09/2021	0.0155	0.0006	12.1993
23/09/2021	0.0155	0.0006	12.1993
24/09/2021	0.0155	0.0005	12.1994
25/09/2021	0.0155	0.0005	12.1994
26/09/2021	0.0155	0.0005	12.1994
27/09/2021	0.0155	0.0004	12.1995
28/09/2021	0.0155	0.0004	12.1995
29/09/2021	0.0155	0.0004	12.1995
30/09/2021	0.0155	0.00043	12.1996
01/10/2021	0.0155	0.0003	12.1996
02/10/2021	0.0155	0.0003	12.1996
03/10/2021	0.0155	0.0003	12.1996
04/10/2021	0.0155	0.0003	12.1996
05/10/2021	0.0155	0.0002	12.1996
06/10/2021	0.0155	0.0002	12.1997
07/10/2021	0.0155	0.0002	12.1997
08/10/2021	0.0155	0.0002	12.1997
09/10/2021	0.0155	0.0002	12.1997
10/10/2021	0.0155	0.0002	12.1997
11/10/2021	0.0155	0.0002	12.1997
12/10/2021	0.0155	0.0001	12.1997
13/10/2021	0.0155	0.0001	12.1998
14/10/2021	0.0155	0.0001	12.1998
15/10/2021	0.0155	0.0001	12.1998
16/10/2021	0.0155	0.0001	12.1998
17/10/2021	0.0155	0.0001	12.1998
18/10/2021	0.0155	0.0001	12.1998
19/10/2021	0.0155	0.0001	12.1998
20/10/2021	0.0155	0.0001	12.1998
21/10/2021	0.0155	0.0001	12.1998
22/10/2021	0.0155	0.0001	12.1998
23/10/2021	0.0155	0.0001	12.1998
24/10/2021	0.0155	0.0001	12.1998
25/10/2021	0.0155	0.0001	12.1998
26/10/2021	0.0155	0.0001	12.1999
27/10/2021	0.0155	0.0000	12.1999

28/10/2021	0.0155	0.0000	12.1999
29/10/2021	0.0155	0.0000	12.1999
30/10/2021	0.0155	0.0000	12.1999
31/10/2021	0.0155	0.0000	12.1999
01/11/2021	0.0155	0.0000	12.1999
02/11/2021	0.0155	0.0000	12.1999
03/11/2021	0.0155	0.0000	12.1999
04/11/2021	0.0155	0.0000	12.1999
05/11/2021	0.0155	0.0000	12.1999
06/11/2021	0.0155	0.0000	12.1999
07/11/2021	0.0155	0.0000	12.1999
08/11/2021	0.0155	0.0000	12.1999
09/11/2021	0.0155	0.0000	12.1999
10/11/2021	0.0155	0.0000	12.1999
11/11/2021	0.0155	0.0000	12.1999
12/11/2021	0.0155	0.0000	12.1999
13/11/2021	0.0155	0.0000	12.1999

Simulation proposed for covid-19 epidemic of Maharashtra start from 29 April 2021.

The maximum number of infected covid-19 cases I_{max} outbreak of Maharashtra can be calculated by equation (2.9)

$$I_{max} = \frac{\alpha}{\beta} \ln(\frac{\alpha}{\beta}) - \frac{\alpha}{\beta} + I_0 + S_0 - \frac{\alpha}{\beta} \ln(S_0)$$

S_0=11.3814181, I_0=0.4539553, β = 0.0398856, α = = 0.0714

Put all the given value in I_{max}

Then I_{max} = 6.7392339. we multiply by 10000000 in $I_{max.}$ Therefore I_{max} = 6.7392339 x 10000000 = 67392339.

And real data point of covid-19 infected at 67344 in table.

In the numerical simulation, we can see the maximum infected population of covid-19 in Maharashtra on the date of 11 may 2021. Then it will continuous decrease till the fourth week of October 2020.

3.2.1 Graphs

In figure (b) show the number of susceptible population of Covid-19 with respect to time t. the maximum number of susceptible are found at initial day on 29 April 2021 (it means initial data S_0) and it is continuous decreasing tends to zero.

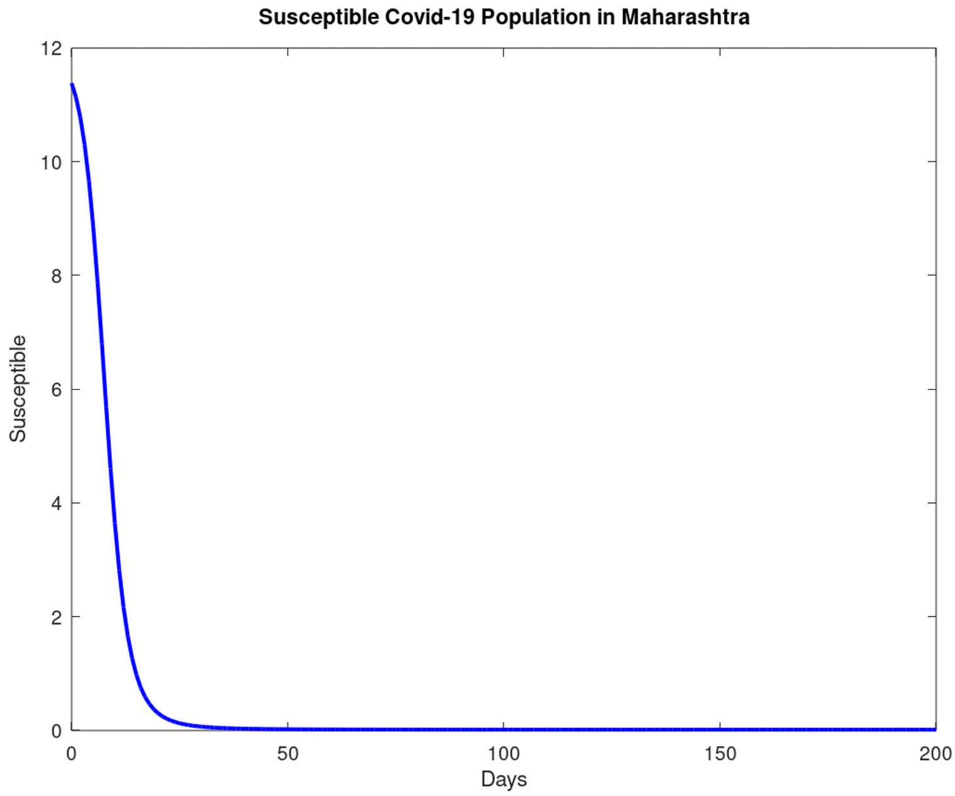


Figure (b); Susceptible population of covid-19

In figure (c) this show the number of infected population of covid-19 with respect to time t. on 29 April 2021 some initial cases after this infected cases continuous increasing till peak on 11 may 2021 and it is continuous decreasing till the end of covied-19 outbreak from Maharashtra.

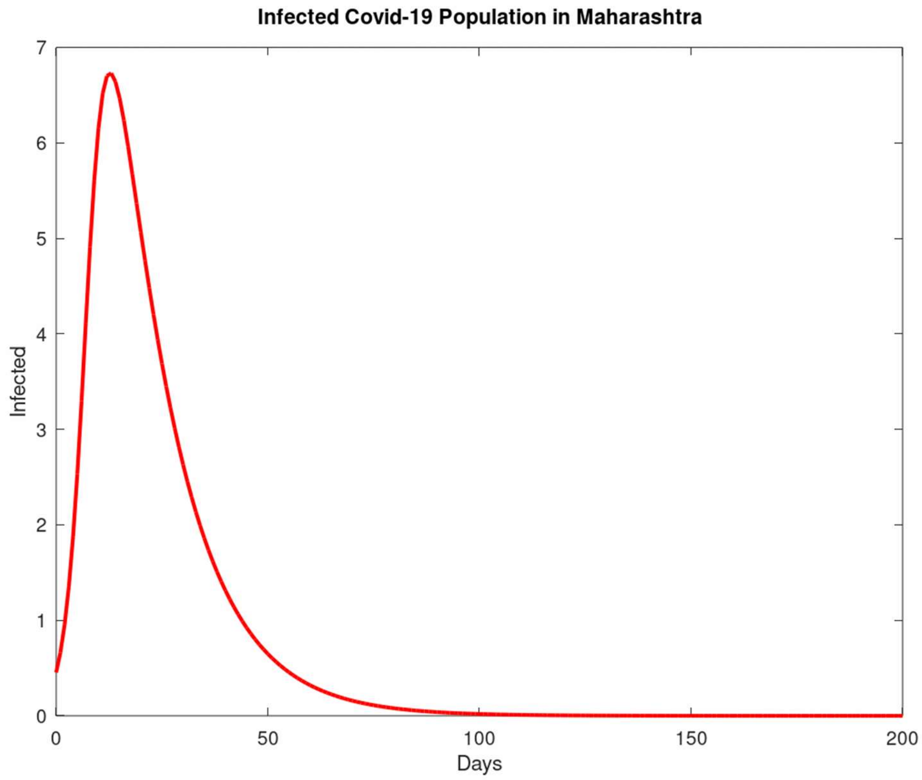


Figure (c) outbreak of infected population of covid-19

Show in figure (d) the number of recovered population of covid-19 with respect to time t. it is very fast in starting and after some reached at peak than recovered rate is constant.

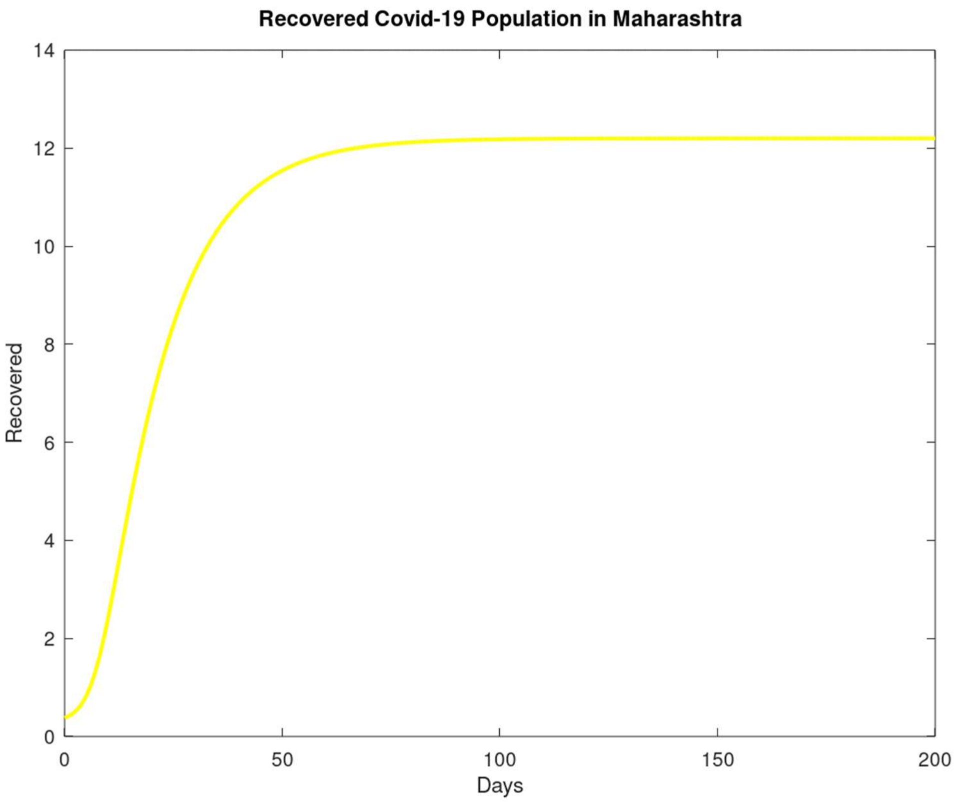


Figure (e); recovered population of covid-19

The spread rate of the Covid-19 outbreak can also be measured at the beginning, height, and end of the epidemic, as well as at any point during the epidemic of covid-19 of Maharashtra. Estimates reproductive number by using equation number (2.5):

1.) Initial level of covid-19

$$R_n = \frac{(\beta * S_0)}{(\alpha)} = \frac{0.0398856 * 11.3814181}{0.0714} = 6.3579088$$

2.) Peak level of covid-19

$$R_n = \frac{(\beta * S_{peak})}{(\alpha)} = \frac{0.0398856*11.3814181}{0.0714} = 6.3579088$$

3.) End level of covid-19

$$R_n = \frac{(\beta * S_{\infty})}{(\alpha)} = \frac{0.0398856*0.0155}{0.0714} = 0.0086586$$

We found that if the reproductive number is $R_n > 1$, the covid-19 increases continuously at the peak point (Cases 1 and 2), whereas if the reproductive number is $R_n < 1$, the covid-19 dies off (case-3). However, the spread of Covid-19 model has been determined by epidemiological scientists all over the India.

CHAPTER 4

Conclusion

According to this Covid-19 model show that covid-19 outbreak will be peak in Maharashtra on 11 may 2021. After the peak value of Covid-19 will decrease slowly till fourth week of October 2021. when the epidemic will be nearing its end. Prediction Based on the data determine through Covid-19 model, it would be incorrect to predict that the covid-19 outbreak in Maharashtra will continue because people here today are not practising social distancing or wearing face masks. As a result, Maharashtra faces a very high risk from this epidemic. This study also demonstrates that if social distancing, and masks, among other things, are used perfectly, then the outbreak of Covid-19 epidemic can be almost terminated in the fourth week of October 2021. In this report, study will be very useful in predicting Covid-19 outbreaks. This model will calculate the number of cases per day automatically. As a result, we can say that the Maharashtra government and doctors can keep an eye on this covid-19 situation.

References

[1.] Tanu Singhal. A review of coronavirus disease-2019 (Covid-19).

[2.] Stephen L. Campbell and Richard Haberman, INTRODUCTION To DIFFERENTIAL EQUATIONS with Dynamical Systems. book

[3.] P Umamaheswari. Stochastic Modelling and Simulation of SIR Model for Covid-19 Epidemic Outbreak in India. Sona College of Arts and Science, Salem-5, India

[4.] Prema Ramachandran Krishnamurthy Kalaivani. Health System Response to Covid-19 Epidemic in India. Annals of the National Academy of Medical Sciences (India)

[5.] Clinical Epidemiology and Global Health Volume 9, January–March 2021.

[6.] Computer oriented numerical methods, R. S. SALARIA, BOOK

[7.] Data collect from my government, Ministry of health and family welfare government of India.

[8.] Data collect from covid-19 India. (https://www.covid19india.org/state/MH)