ANALYSIS AND PROGNOSIS OF COVID-19 USING SEIR MODEL

A Project Report submitted to the

DEPARTMENT OF MATHEMATICS WITH COMPUTER APPLICATIONS

PSG COLLEGE OF ARTS & SCIENCE (AUTONOMOUS)

IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR

THE AWARD OF THE DEGREE OF

BACHELOR OF SCIENCE

(MATHEMATICS WITH COMPUTER APPLICATIONS)

SUBMITTED BY

20BMC009 **JANANY P**

20BMC036 **VISMAYA K**

UNDER THE GUIDANCE OF

Mrs. V. UMAMAHESWARI, M.Sc., M.Phil.,

DEPARTMENT OF MATHEMATICS WITH COMPUTER APPLICATIONS

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DECEMBER - 2022

DECLARATION

We hereby declare that the project report entitled

"ANALYSIS AND PROGNOSIS OF COVID-19 USING SEIR MODEL"

submitted to PSG College of Arts & Science, Coimbatore - 14, in partial fulfillment of the requirements for the award of the Degree of **Bachelor of Science** in **Mathematics with Computer Applications**, is a record of original work done by us during the period 2022−2023 under the guidance of

Mrs. V. UMAMAHESWARI, M.Sc., M.Phil.,,

Assistant Professor, Department of Mathematics with Computer Applications, PSG College of Arts & Science, Coimbatore−641 014 and it has not formed on the basis for award of any Degree/ Diploma/ Associate ship/
Fellowship or other similar title to any candidate of any university.

Place: Coimbatore

Signature of the Candidates

Date: 28.11.2022

JANANY P (20BMC009)

VISMAYA K(20BMC036)

CERTIFICATE

This is to certify that this project work entitled

"ANALYSIS AND PROGNOSIS OF COVID-19 USING SEIR MODEL"

submitted to PSG College of Arts & Science, in partial fulfillment of the requirements for the award of the Degree of **Bachelor of Science in Mathematics with Computer Applications**, of the Bharathiar University, Coimbatore, is a record of original work done by the following candidates.

JANANY P(20BMC009) &
VISMAYA K (20BMC036)

during the period 2022−2023 of their study in the **Department of Mathematics with Computer Applications,** PSG College of Arts & Science (Autonomous), Coimbatore, under my supervision and the Project work has not formed the basis for the award of any Degree/Diploma/Associate ship/Fellowship or other similar title to any candidate of any University.

Place: Coimbatore
Date: 28.11.2022 Signature of the Guide

Counter Signed

Head of the Department

Viva voce Conducted on: 05.12.2022

Internal Examiner **External Examiner**

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JANANY P, 20BMC009
VISMAYA K, 20BMC036

Abstract

Our aim is to predict the covid-19 or similar epidemic and analyze the progression of cases futuristic using a mathematical model called Susceptible-Exposed-Infected-Recovered(SEIR) model. SEIR model is a proved theoretical framework to investigate the spread of the covid-19 or similar epidemic. Thus, it helps us to predict and take adequate measures to further prevent and control the spread of such epidemics. This study can help the government and medical fraternity to implement selective restrictions based on the prediction.

Contents

Chapter 1

INTRODUCTION

1.1 COVID-19

Coronavirus disease (COVID-19) is an infectious disease caused by the SARS-CoV-2 virus. Most people infected with the virus will experience mild to moderate respiratory illness and recover without requiring special treatment. However, some will become seriously ill and require medical attention. Older people and those with underlying medical conditions like cardiovascular disease, diabetes, chronic respiratory disease, or cancer are more likely to develop serious illness. Anyone can get sick with COVID-19 and become seriously ill or die at any age. The best way to prevent and slow down transmission is to be well informed about the disease and how the virus spreads. Protect yourself and others from infection by staying at least 1 meter apart from others, wearing a properly fitted mask, and washing your hands or using an alcohol-based rub frequently. Get vaccinated when it's your turn and follow local guidance. The virus can spread from an infected person's mouth or nose in small liquid particles when they cough, sneeze, speak, sing or breathe. These particles range from larger respiratory droplets to smaller aerosols. It is important to practice respiratory etiquette, for example by coughing into a flexed elbow, and to stay home and self-isolate until you recover if you feel unwell.

1.2 USAGE OF MATHEMATICAL MODEL

A mathematical model is a "Mathematical framework representing variables and their interrelationships to describe observed phenomena or predict future events." For the modelling studies that are most relevant to evidence synthesis and clinical and public health decision-making, the framework of the mathematical model represents interrelationships among expo-

sure risks, interventions, health outcomes, and health costs (all of these are variables) where their interrelationships are typically described by the parameters of interest.

1.3 HOW SEIR COMES TO PLAY

At the end of 2019, a novel coronavirus disease (COVID-19) was declared as a major health hazard by World Health Organization (WHO). At present, this disease is rapidly growing in many countries, and the global number of COVID-19 cases is increasing at a rapid rate. This coronavirus is a kind of enveloped, single stranded and positive sense virus which belongs to the RNA coronaviridae family. In early December of 2019, this infectious disease has begun to outbreak in Wuhan, the capital city of Hubei province, China. Until now, the epidemic in China is basically under control, but there are still many infections around the world. To defeat the epidemic, scientists in different fields investigated the COVID-19 from different points of view. Those aspects include pathology, sociology perspective, the infection mechanism and prediction.

How to build a proper epidemiological model for these epidemics is a challenging task. Some scientists treat the disease spread as a complex network for forecast and modelling. For the COVID-19, Bastian Prasse et al. designed a network-based model which is built by the cities and traffic flow to describe the epidemic in the Hubei province. At present, the SIS, SIR and SEIR models provide another way for the simulation of epidemics. Lots of research works have been reported. It shows that those SIS, SIR and SEIR models can reflect the dynamics of different epidemics well. Meanwhile, these models have been used to model the COVID-19. For instance, Tang et al.Investigated a general SEIR-type epidemiological model where quarantine, isolation and treatment are considered. Moreover, there are also other methods for modelling of the COVID-19 Wang et al, Applied the phase-adjusted estimation for the number of coronavirus disease 2019 cases in Wuhan. Thus in this study, we try to propose a SEIR model to simulate the process of COVID-19.

Chaos widely exits in nature and man-made systems including those biological systems. According to the famous Logistic map, it shows that the natural evolution of the population size could be chaotic. However, it is not a good thing to find chaos in the SEIR model. Unfortunately, chaos in the SIR, SIS and SEIR models has been investigated by many researchers. Generally, the seasonality and stochastic infection are introduced to the system for the nonlinear dynamics. For instance, Kuznetsova and Piccardi investigated the bifurcations of the periodic

solutions of SEIR and SIR epidemic models with sinusoidally varying contact rate. Meanwhile, the fractional-order SEIR epidemic model has aroused research interests of scientists. He et al investigated the epidemic outbreaks using the SIR model, and a hard limited controller is designed for the control of the system. However, on the one hand, those SIR and SEIR models cannot always show the nature of the COVID-19, and we need to modify the system. On the other hand, the nonlinear dynamics of the system should be investigated. Thus, we need to get more information on the dynamics of the epidemic system.

The modified SEIR model is designed and the descriptions of the system are presented. The SEIR model is applied to the COVID-19 data and algorithm is introduced to estimate the parameters. The seasonality infection are introduced to the model and the dynamics of the system is investigated. The structure, parameters on the dynamics of the system and how to control the epidemic of the system are discussed.

Chapter 2

SEIR MATHEMATICAL MODEL

In the study, a mathematical model of the spread and transmission of SARS-CoV-2 was formulated. We consider two interacting populations, the human population as hosts and the pathogens. The model subdivides the total human population size at time t denoted as N(t) into susceptible S(t), exposed E(t), infected I(t) and the recovered as R(t). The pathogen in the environment is denoted as P(t). Hence for the human population we have.

$$N(t) = S(t) + E(t) + I(t) + R(t)$$

N: total population

S(t): number of people susceptible on day t

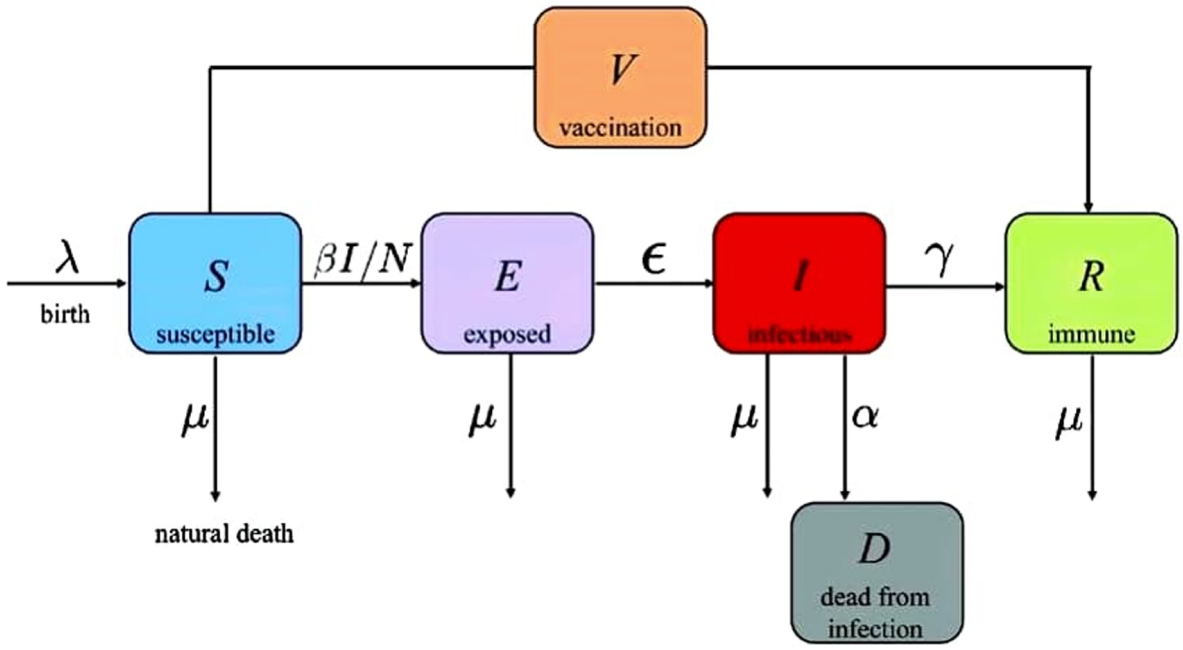
E(t): number of people exposed on day t

I(t): number of people infected on day t

R(t): number of people recovered on day t

2.1 COMPARTMENTAL SEIR MODEL

The compartmental model depicting the interaction between the human population and pathogens in the environment as shows



The SEIR model parameters are:

- Alpha(α) is a disease-induced average fatality rate.
- Beta(β) is the probability of disease transmission per contact times the number of contacts per unit time.
- Epsilon(ϵ) is the rate of progression from exposure to infectious. It is the reciprocal of the incubation period.
- Gamma(γ) is the recovery rate. It's the inverse of the infectious period.

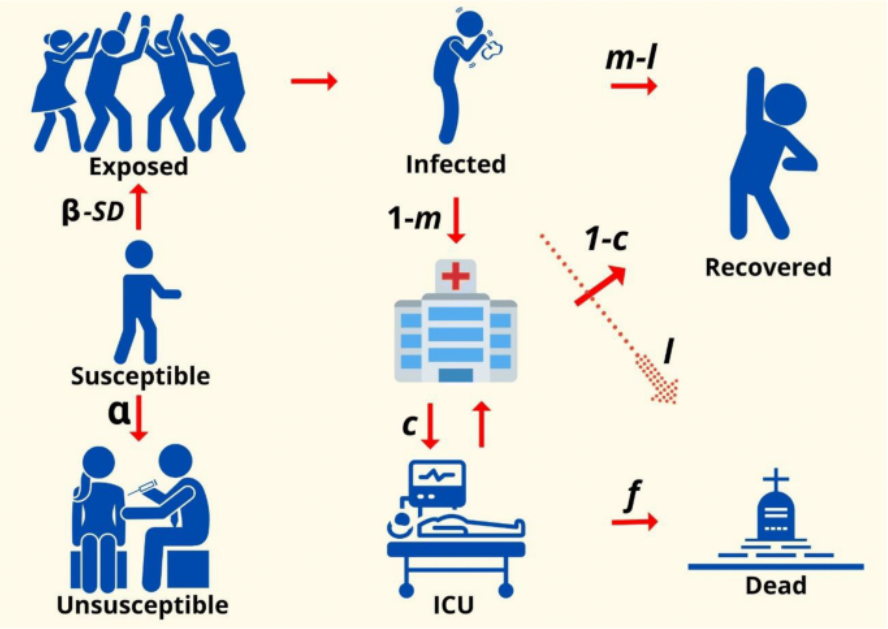
We need to know the above parameters as well as the following values at the beginning:

- Exposed count
- Infectious count
- Recovered count
- Death count

Chapter 3

SEIRD MATHEMATICAL MODEL

SEIRD models: SEIRD models are mathematical models of the spread of an infectious disease. Every individual in a population is in one of five states. They are either susceptible (S) to the disease, exposed (E) to the disease, infected (I) by the disease, or who have recovered (R) or died (D) from the disease. In this context, we assume an exposed individual is 'pre-symptomatic', i.e., they can spread the disease but have not yet tested positive for it, while infected individuals are symptomatic and have tested positive for the disease.



3.1 SEIRD COMPARTMENTAL MODEL

Having an accurate understanding of the spread of COVID-19 is essential to containing the virus effectively, and necessary for the deployment and allocation of resources. In order to understand why the spread appears to differ between communities, we require a mathematical

model of disease spread capable of expressing the differences. A standard model of disease spread is the SEIRD model, in which each individual is either susceptible (S), exposed (E), infected (I), recovered (R), or dead (D). Compartmental SEIRD models consider only the aggregate number of individuals with each disease state, and specify a set of differential equations that govern how the compartmental populations change with time.

3.2 FORMULAS FOR SEIRD MODEL

Five differential equations describe how the numbers of people in these groups change with time. We only consider the simplified version rather than the rigorous one because we ignore the birth rate and the death rate from other causes.

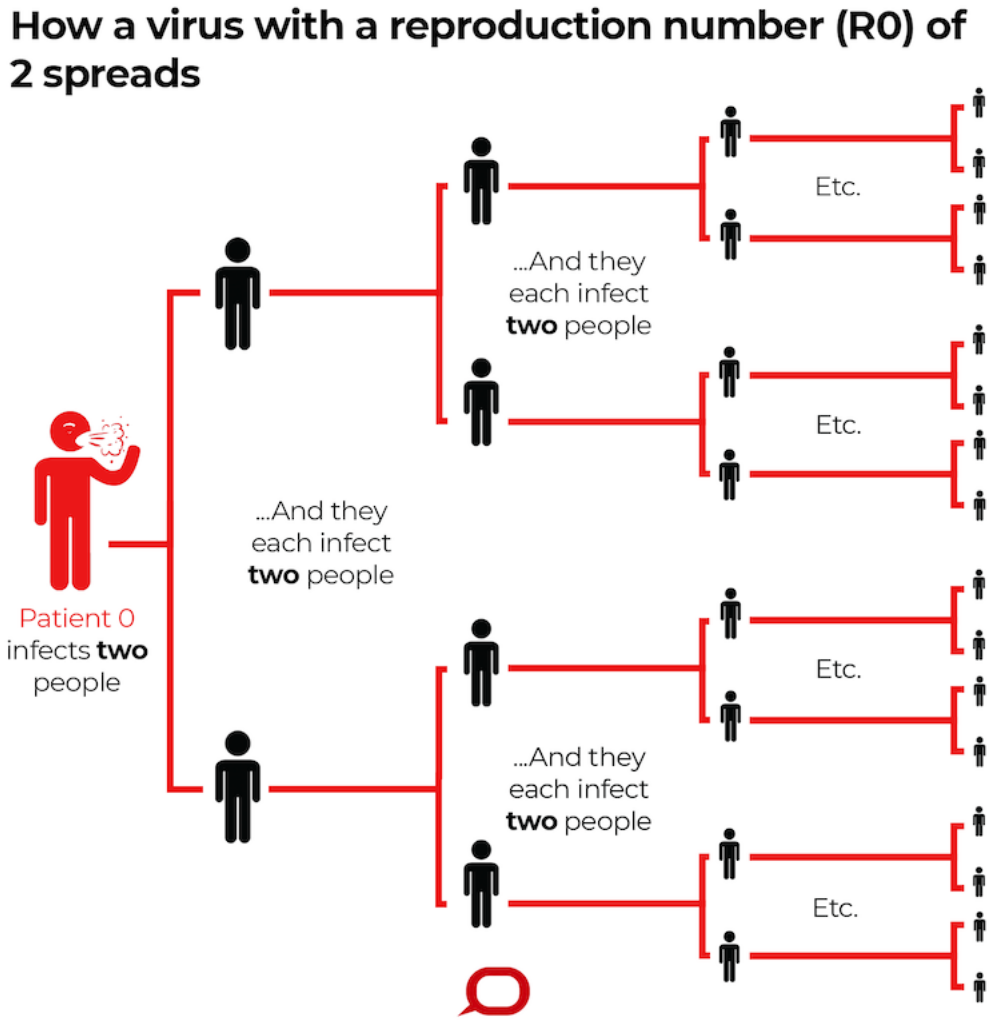
$$\begin{aligned}
\frac{dS}{dt} &= -\beta S \frac{I}{N} \\
\frac{dE}{dt} &= \beta S \frac{I}{N} - \epsilon E \\
\frac{dI}{dt} &= \epsilon E - (\gamma + \alpha) I \\
\frac{dR}{dt} &= \gamma I \\
\frac{dD}{dt} &= \alpha I
\end{aligned}$$

We transform SEIR differential equations into the difference equations here.

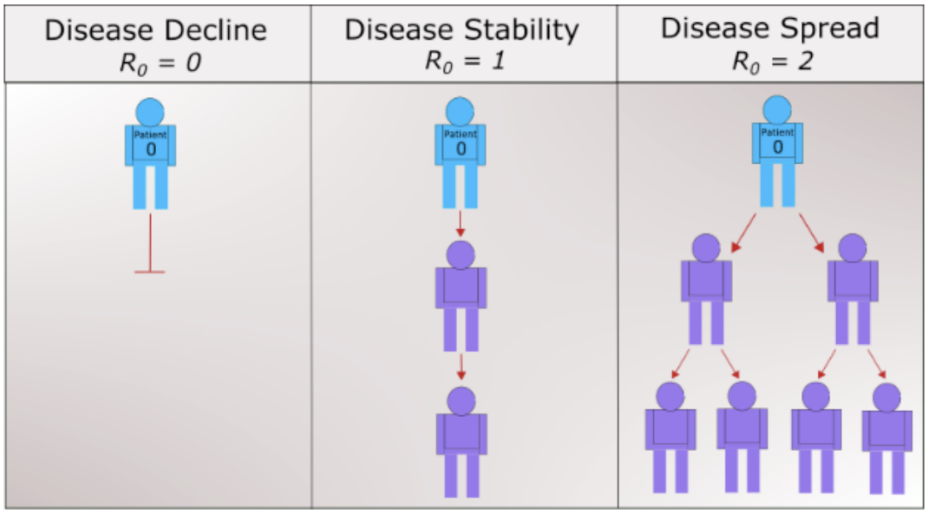
$$\begin{aligned}
\Delta S &= -\Delta t \beta S \frac{I}{N} \\
\Delta E &= \Delta t (\beta S \frac{I}{N} - \epsilon E) \\
\Delta I &= \Delta t (\epsilon E - (\gamma + \alpha) I) \\
\Delta R &= \Delta t (\gamma I) \\
\Delta D &= \Delta t (\alpha I)
\end{aligned}$$

There are two metrics related to COVID-19. The reproduction rate (R0) is the average number of secondary cases generated by an infectious individual. If we ignore the natural birth rate and fatalities from other causes, the following equation describes the reproduction rate:

$$R_0 = \frac{\beta}{(\gamma+\alpha)}$$



If R0 is less than 1, the disease stops. If R0 is greater than 1, the disease continues spreading.



The other one is infection and case fatality rate (IFR). The following equation describes IFR

$$IFR = \frac{\alpha}{\gamma}$$

Chapter 4

JAVA

4.1 INTRODUCTION TO JAVA

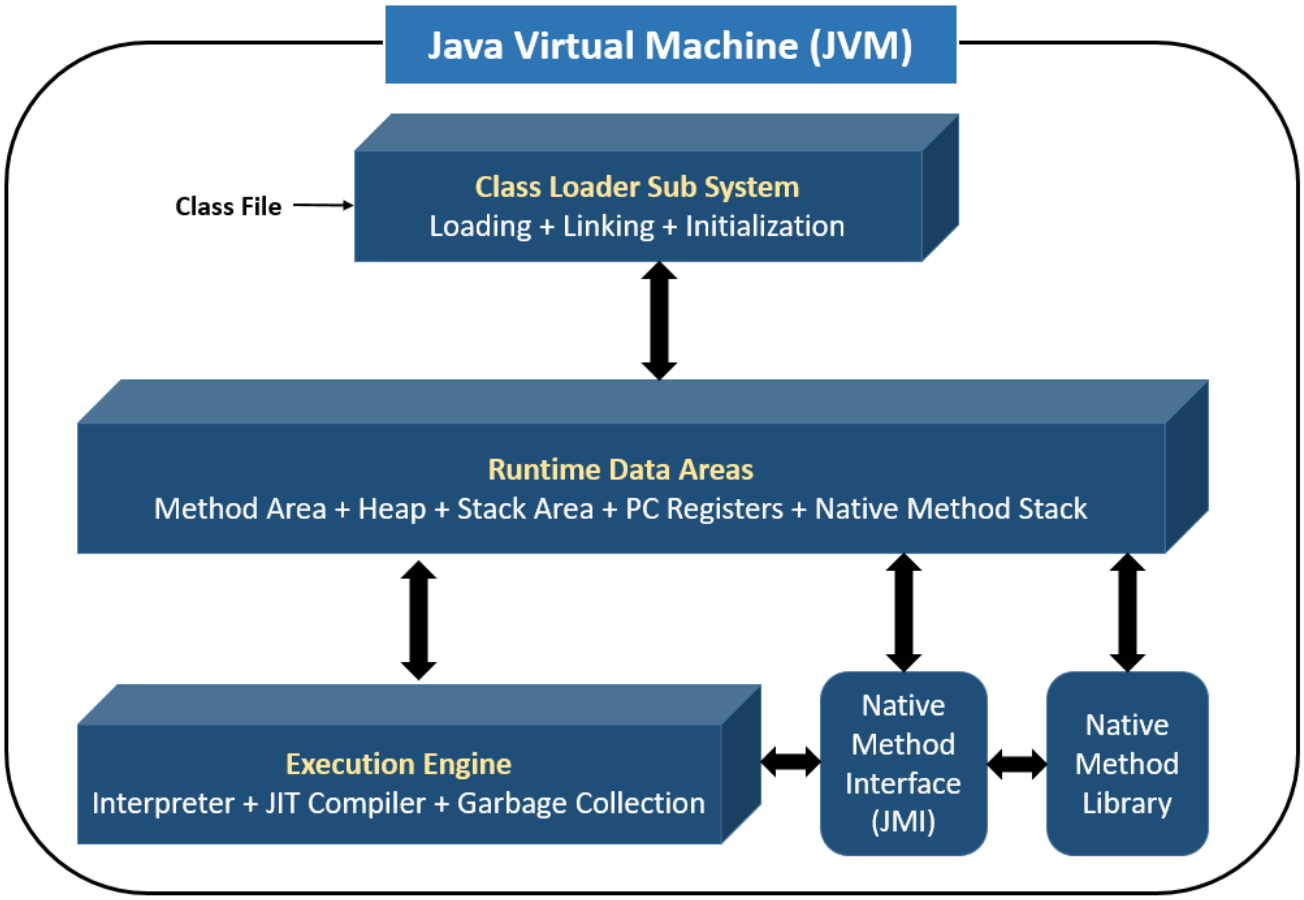
JAVA was developed by Sun Microsystems Inc in 1991, later acquired by Oracle Corporation. It was developed by James Gosling and Patrick Naughton. It is a simple programming language. Writing, compiling and debugging a program is easy in java. It helps to create modular programs and reusable code. Java is a class-based, object-oriented programming language and is designed to have as few implementation dependencies as possible. A general-purpose programming language made for developers to write once run anywhere that is compiled Java code can run on all platforms that support Java. Java applications are compiled to byte code that can run on any Java Virtual Machine. The syntax of Java is similar to c/c++.

4.2 JAVA ENVIRONMENT

4.2.1 Java Virtual Machine (JVM)

- Java Virtual Machine (JVM) is an abstract machine responsible for compiling and executing Java code. It is a part of the Java Runtime Environment (JRE) which calls the main function of a program.
- JVM facilitates a platform-independent way of executing Java source code. Its basis on WORA (Write Once Run Anywhere).
- It has a class loader, runtime data area, execution engine, and libraries.
- JVM comes with JIT(Just-in-Time) compiler that converts Java source code into machine code.

- First, the java compiler compiles a Java file into a Java .class file. Then the .class file works as an input into the JVM, which loads and executes the class file.



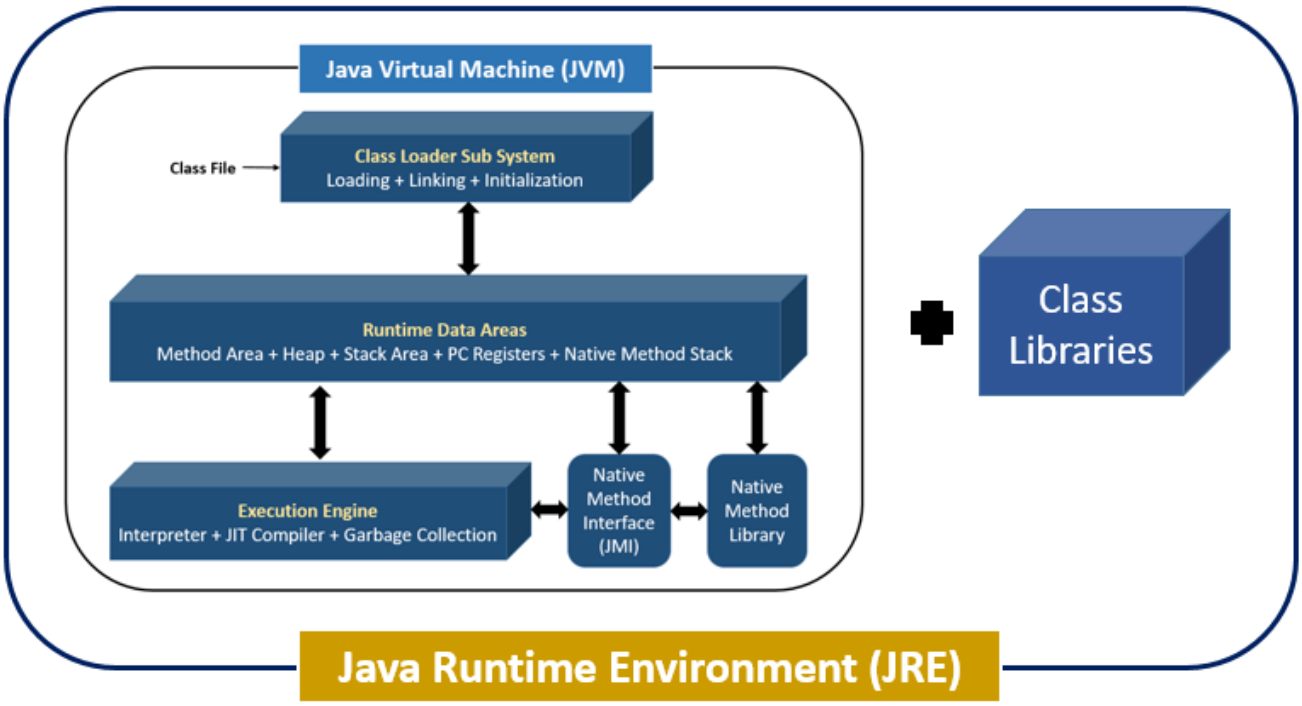
Features of JVM

- It converts byte code to the machine language.
- JVM provides basic java functions like memory management, security, garbage collection, etc.
- Runs the program by utilizing JRE's libraries and files.
- JVM is an integral part of JRE.
- It can execute the java program line by line. Therefore, it is also known as an interpreter.
- It can execute the java program line by line. Therefore, it is also known as an interpreter.

4.2.2 Java Runtime Environment (JRE)

- JRE is software that includes JVM and class libraries to run java programs independently. Although it can execute the code. Yet, JRE comes bundled with Java development Kit (JDK) to provide a complete application development experience.
- The JRE includes class libraries along with JVM and its supporting files. Note: It does not include separate tools such as a debugger for Java development.
- JRE comprises significant package classes such as util, math, AWT, Lang, and various runtime libraries.

JRE = JVM + Class Libraries (For Running the Java Applications).



Features of JRE

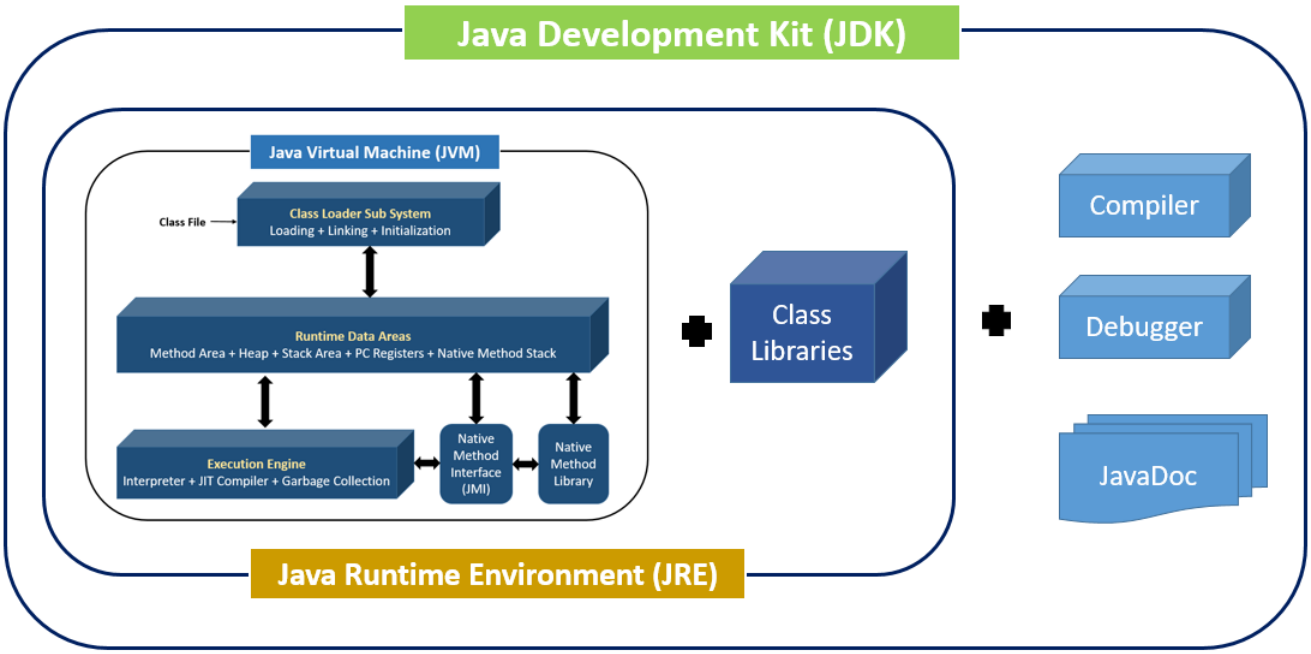
- JRE consists of a set of tools to help the JVM run. In addition, it includes a few deployment tools such as Java Plug-in and Java Web Start.
- A User can efficiently run a java code with JRE only. However, JRE doesn't allow writing the program.
- JRE appends various integration libraries like the JDBC (Java Database Connectivity), JNDI (Java Naming and Directory Interface), RMI (Remote Method Invocation), etc.

- Along with JVM, it consists of a virtual machine client for Java HotSpot.

4.2.3 Java Development Kit (JDK)

- Java Development Kit (JDK) is a complete software environment for building applications and applets using the Java programming language. It is platform-dependent. Therefore, it has different OS platform versions for Windows, Linux, Mac, etc. It allows to read, write, and execute the java program.
- It includes various tools required for writing Java programs.
- It includes an Applet viewer, Java application launcher, debugger, compiler, etc.
- JDK also consists of JRE for executing Java programs.
- The Java application launcher helps in opening a JRE. Then, it loads the necessary details and executes the main method of the program.

JDK = Development Tools + JRE (Java Runtime Environment)



Features of JDK

- JDK provides an environment for developing and executing the Java source code.
- It includes all the functionalities of JRE and JVM.
- JDK helps developers to handle the exceptions using multiple extensions in a single catch block.
- It has various other development tools like the debugger, compiler, etc.

It is platform-dependent. Moreover, any user can easily install JDK on Operating systems like Unix, Mac, Windows, etc.

Chapter 5

WORKING IN JAVA

5.1 JAVA CODE FOR SEIRD MODEL

```
import java.util.ArrayList;
import java.util.List;

public class model {

    int totalDays = 200; // Days to simulate
    int N = 4132000; // Population
    // SEIR model variables
    int I0 = 1; // Infected initial
    int E0 = 1; // Exposed initial
    double beta = 0.5; // Infection rate
    double gamma = 0.1; // Recovery time
    double epsilon = 0.5; //Incubation period
    double alpha = 0.0005; // Death rate

    List<Double> S = new ArrayList<>();
    List<Double> E = new ArrayList<>();
    List<Double> I = new ArrayList<>();
    List<Double> R = new ArrayList<>();
    List<Double> D = new ArrayList<>();
    List<Double> RR = new ArrayList<>();
    List<Double> IFR = new ArrayList<>();
```

```
private void initialvaluemodel(){
    final int R0 = 0;
    final int D0 = 0;
    final int RR0 = 0;
    final int IFR0 = 0;
    final int S0 = N-E0-I0-R0-D0; //Susceptible
       population(Population-Exposed-Infected-Recovered-Death)



       // Adding the initial values
       S.add((double) S0);
       E.add((double) E0);
       I.add((double) I0);
       R.add((double) R0);
       D.add((double) D0);
       RR.add((double) RR0);
       IFR.add((double) IFR0);

       for (int day=1; day<totalDays+1; day++) {
         double[]equation = calculomodel(day);
          S.add(equation[0]);
          E.add(equation[1]);
          I.add(equation[2]);
          R.add(equation[3]);
          D.add(equation[4]);
          RR.add(equation[5]);
          IFR.add(equation[6]);



           // Printing the values for S, E, I, R, D, RR and IFR day by day
           System.out.println("\n"+"S: "+S.get(day)+" in day: "+day+"\n");
           System.out.println("E: "+E.get(day)+" in day: "+day+"\n");
```

```
            System.out.println("I: "+I.get(day)+" in day: "+day+"\n");
            System.out.println("R: "+R.get(day)+" in day: "+day+"\n");
            System.out.println("D: "+D.get(day)+" in day: "+day+"\n");
            System.out.println("RR: "+RR.get(day)+" in day: "+day+"\n");
            System.out.println("IFR: "+IFR.get(day)+" in day: "+day+"\n"+"\n");

        }

       }

       private double[] calculomodel(int day) {
        day = day - 1;
        double dS = (beta * S.get(day) * I.get(day)) / N;
        double newS = S.get(day) - (dS);
        double newE = E.get(day) + (dS - (epsilon * E.get(day)));
        double newI = I.get(day) + ((epsilon * E.get(day)) - ((gamma + alpha)*
            I.get(day)));
        double newR = R.get(day) + (gamma * I.get(day));
        double newD = D.get(day) + (alpha * I.get(day));
        double newRR = RR.get(day) + beta/(gamma + alpha);
        double newIFR = IFR.get(day) + alpha/gamma;
        return new double[] {newS, newE, newI, newR, newD, newRR, newIFR};
    }

     public model(){
         initialvaluemodel();
    }

    public static void main(String[] args) {
        new model();
    }
}
```

5.2 JAVA CODE OUTPUT FOR SEIRD MODEL

SEIRD JAVA OUTPUT:

S: 4131997.500000242 in day: 1
E: 0.9999997579864472 in day: 1
I: 1.3995 in day: 1
R: 0.1 in day: 1
D: 5.0E-4 in day: 1
RR: 4.975124378109452 in day: 1
IFR: 0.005 in day: 1

S: 4131993.478687364 in day: 5
E: 2.266474129577868 in day: 5
I: 3.3460538396961486 in day: 5
R: 0.9042633500227165 in day: 5
D: 0.004521316750113582 in day: 5
RR: 24.87562189054726 in day: 5
IFR: 0.025 in day: 5

S: 4131980.061378639 in day: 10
E: 6.595570992252715 in day: 10
I: 9.737378967229262 in day: 10
R: 3.5877327379804496 in day: 10
D: 0.017938663689902247 in day: 10
RR: 49.75124378109453 in day: 10
IFR: 0.049999999999999996 in day: 10

S: 4131941.016000153 in day: 15
E: 19.193560636737658 in day: 15
I: 28.336579859164896 in day: 15
R: 11.39687497655 in day: 15
D: 0.056984374882749995 in day: 15
RR: 74.62686567164181 in day: 15
IFR: 0.075 in day: 15

S: 4131827.3930839947 in day: 20
E: 55.85340270134912 in day: 20
I: 82.46087617139113 in day: 20
R: 34.12202699736777 in day: 20
D: 0.17061013498683886 in day: 20
RR: 99.50248756218909 in day: 20
IFR: 0.10000000000000002 in day: 20

S: 4131496.764750142 in day: 25
E: 162.52394328158368 in day: 25
I: 239.95751823843628 in day: 25
R: 100.25252570896744 in day: 25
D: 0.5012626285448373 in day: 25
RR: 124.37810945273637 in day: 25
IFR: 0.12500000000000003 in day: 25

S: 4130534.8208814114 in day: 30
E: 472.83359302338283 in day: 30
I: 698.1998581611081 in day: 30
R: 292.68225612342303 in day: 30
D: 1.4634112806171151 in day: 30
RR: 149.25373134328365 in day: 30
IFR: 0.15000000000000005 in day: 30

S: 4127737.309881501 in day: 35
E: 1374.9155281030705 in day: 35

I: 2030.9807024179445 in day: 35
R: 852.5312318191378 in day: 35
D: 4.262656159095689 in day: 35
RR: 174.12935323383093 in day: 35
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S: 4119611.8436272508 in day: 40
E: 3992.034910090989 in day: 40
I: 5903.162092673222 in day: 40
R: 2480.556587050144 in day: 40
D: 12.402782935250718 in day: 40
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IFR: 0.2000000000000001 in day: 40

S: 4096097.1241245135 in day: 45
E: 11540.540942885302 in day: 45
I: 17118.08408183851 in day: 45
R: 7208.209801754215 in day: 45
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S: 4028761.9722697134 in day: 50
E: 32945.4781276303 in day: 50
I: 49306.63073622278 in day: 50
R: 20881.511309883972 in day: 50
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IFR: 0.2500000000000001 in day: 50

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IFR: 0.27500000000000013 in day: 55

S: 3364219.8990362883 in day: 60
E: 225893.22128108476 in day: 60
I: 372952.50573681365 in day: 60
R: 168093.90442369453 in day: 60
D: 840.4695221184727 in day: 60
RR: 298.5074626865673 in day: 60
IFR: 0.30000000000000016 in day: 60

S: 2385804.1450405777 in day: 65
E: 433705.03487025294 in day: 65
I: 868296.511483643 in day: 65
R: 441984.386672165 in day: 65
D: 2209.921933360825 in day: 65
RR: 323.3830845771146 in day: 65
IFR: 0.3250000000000002 in day: 65

S: 1142065.5789997953 in day: 70
E: 480074.8471114413 in day: 70
I: 1497953.8652088596 in day: 70
R: 1006871.3519203019 in day: 70
D: 5034.356759601509 in day: 70
RR: 348.25870646766185 in day: 70
IFR: 0.3500000000000002 in day: 70

S: 382475.6736227116 in day: 75
E: 248431.8028771699 in day: 75
I: 1673365.4365313526 in day: 75
R: 1818633.9173818561 in day: 75
D: 9093.16958690928 in day: 75
RR: 373.13432835820913 in day: 75

IFR: 0.3750000000000002 in day: 75

S: 135067.55385836883 in day: 80
E: 77239.67342819064 in day: 80
I: 1311875.5832946203 in day: 80
R: 2594842.9745460893 in day: 80
D: 12974.214872730445 in day: 80
RR: 398.0099502487564 in day: 80
IFR: 0.40000000000000024 in day: 80

S: 64758.74862731602 in day: 85
E: 22812.187392238295 in day: 85
I: 869419.2542094161 in day: 85
R: 3159213.7410657 in day: 85
D: 15796.0687053285 in day: 85
RR: 422.8855721393037 in day: 85
IFR: 0.42500000000000027 in day: 85

S: 40816.92725045753 in day: 90
E: 8061.622110471121 in day: 90
I: 542232.9308333958 in day: 90
R: 3523272.1590106217 in day: 90
D: 17616.360795053108 in day: 90
RR: 447.76119402985097 in day: 90
IFR: 0.4500000000000003 in day: 90

S: 30849.27657858738 in day: 95
E: 3443.1567446524605 in day: 95
I: 330800.29699588765 in day: 95
R: 3748166.4374934044 in day: 95
D: 18740.832187467026 in day: 95
RR: 472.63681592039825 in day: 95
IFR: 0.4750000000000003 in day: 95

S: 26072.208295942375 in day: 100
E: 1678.6131727679117 in day: 100
I: 199982.40816160775 in day: 100
R: 3884842.557581772 in day: 100
D: 19424.212787908862 in day: 100
RR: 497.5124378109455 in day: 100
IFR: 0.5000000000000003 in day: 100

S: 23571.35387444313 in day: 105
E: 888.465059879694 in day: 105
I: 120380.558350157 in day: 105
R: 3967323.007677133 in day: 105
D: 19836.615038385673 in day: 105
RR: 522.3880597014927 in day: 105
IFR: 0.5250000000000004 in day: 105

S: 22189.873614304284 in day: 110
E: 494.1480900729814 in day: 110
I: 72303.44607875095 in day: 110
R: 4016927.8927531047 in day: 110
D: 20084.639463765536 in day: 110
RR: 547.2636815920397 in day: 110
IFR: 0.5500000000000004 in day: 110

S: 21401.64626982986 in day: 115
E: 283.1214219306111 in day: 115
I: 43374.49776950661 in day: 115
R: 4046707.198546001 in day: 115
D: 20233.53599273002 in day: 115
RR: 572.1393034825867 in day: 115
IFR: 0.5750000000000004 in day: 115

S: 20943.090607898564 in day: 120
E: 165.1233806252343 in day: 120

I: 26002.226244063128 in day: 120
R: 4064566.7261367277 in day: 120
D: 20322.833630683657 in day: 120
RR: 597.0149253731337 in day: 120
IFR: 0.6000000000000004 in day: 120

S: 20673.19953118496 in day: 125
E: 97.33411903744377 in day: 125
I: 15581.631008955603 in day: 125
R: 4075271.4779510647 in day: 125
D: 20376.357389755347 in day: 125
RR: 621.8905472636807 in day: 125
IFR: 0.6250000000000004 in day: 125

S: 20513.238439565564 in day: 130
E: 57.74144876186149 in day: 130
I: 9334.976665305763 in day: 130
R: 4081685.615369517 in day: 130
D: 20408.42807684761 in day: 130
RR: 646.7661691542277 in day: 130
IFR: 0.6500000000000005 in day: 130

S: 20418.03450535994 in day: 135
E: 34.38478573596154 in day: 135
I: 5591.819264866569 in day: 135
R: 4085528.120839836 in day: 135
D: 20427.640604199205 in day: 135
RR: 671.6417910447747 in day: 135
IFR: 0.6750000000000005 in day: 135

S: 20361.230051803384 in day: 140
E: 20.522799144835826 in day: 140
I: 3349.3232867894967 in day: 140
R: 4087829.774987323 in day: 140
D: 20439.148874936647 in day: 140
RR: 696.5174129353217 in day: 140
IFR: 0.7000000000000005 in day: 140

S: 20327.286217797435 in day: 145
E: 12.265935540080449 in day: 145
I: 2006.039922144325 in day: 145
R: 4089208.3660940453 in day: 145
D: 20446.041830470258 in day: 145
RR: 721.3930348258687 in day: 145
IFR: 0.7250000000000005 in day: 145

S: 20306.984662495026 in day: 150
E: 7.337031212569 in day: 150
I: 1201.4598580958352 in day: 150
R: 4090034.048207158 in day: 150
D: 20450.170241035827 in day: 150
RR: 746.2686567164156 in day: 150
IFR: 0.7500000000000006 in day: 150

S: 20294.835922293398 in day: 155
E: 4.390894639868089 in day: 155
I: 719.5671004907595 in day: 155
R: 4090528.5632662424 in day: 155
D: 20452.642816331245 in day: 155
RR: 771.1442786069626 in day: 155
IFR: 0.7750000000000006 in day: 155

S: 20287.563601393427 in day: 160
E: 2.6285316092163837 in day: 160
I: 430.95184911857825 in day: 160
R: 4090824.7323560957 in day: 160
D: 20454.123661780508 in day: 160
RR: 796.0199004975096 in day: 160

IFR: 0.8000000000000006 in day: 160

S: 20283.209499548728 in day: 165
E: 1.5738008384693851 in day: 165
I: 258.09729608412863 in day: 165
R: 4091002.10885923 in day: 165
D: 20455.01054429618 in day: 165
RR: 820.8955223880566 in day: 165
IFR: 0.8250000000000006 in day: 165

S: 20280.602299862334 in day: 170
E: 0.9423930711062537 in day: 170
I: 154.57402590936988 in day: 170
R: 4091108.339583238 in day: 170
D: 20455.541697916226 in day: 170
RR: 845.7711442786036 in day: 170
IFR: 0.8500000000000006 in day: 170

S: 20279.04102254636 in day: 175
E: 0.56434124476435 in day: 175
I: 92.57390811855394 in day: 175
R: 4091171.96092347 in day: 175
D: 20455.859804617387 in day: 175
RR: 870.6467661691506 in day: 175
IFR: 0.8750000000000007 in day: 175

S: 20278.106039369202 in day: 180
E: 0.3379620269191379 in day: 180
I: 55.442153306932084 in day: 180
R: 4091210.063527656 in day: 180
D: 20456.050317638317 in day: 180
RR: 895.5223880596976 in day: 180
IFR: 0.9000000000000007 in day: 180

S: 20277.546103460914 in day: 185
E: 0.20239689539675498 in day: 185
I: 33.2040628866419 in day: 185
R: 4091232.8830216466 in day: 185
D: 20456.16441510827 in day: 185
RR: 920.3980099502446 in day: 185
IFR: 0.9250000000000007 in day: 185

S: 20277.21076814368 in day: 190
E: 0.1212120151998736 in day: 190
I: 19.885758221393466 in day: 190
R: 4091246.5495140473 in day: 190
D: 20456.232747570273 in day: 190
RR: 945.2736318407916 in day: 190
IFR: 0.9500000000000007 in day: 190

S: 20277.009940202388 in day: 195
E: 0.07259237761666454 in day: 195
I: 11.909484276134737 in day: 195
R: 4091254.734311584 in day: 195
D: 20456.273671557956 in day: 195
RR: 970.1492537313386 in day: 195
IFR: 0.9750000000000008 in day: 195

S: 20276.889666330564 in day: 200
E: 0.043474888940461004 in day: 200
I: 7.132531201550005 in day: 200
R: 4091259.636146843 in day: 200
D: 20456.29818073425 in day: 200
RR: 995.0248756218856 in day: 200
IFR: 1.0000000000000007 in day: 200

Chapter 6

MATLAB SOFTWARE

6.1 INTRODUCTION TO MATLAB

MATLAB stands for Matrix Laboratory. MATLAB was written initially to implement a simple approach to matrix software developed by the LINPACK (Linear system package) and EISPACK (Eigen system package) projects. MATLAB is a modern programming language environment, and it has refined data structures, includes built-in editing and debugging tools, and supports object-oriented programming. MATLAB is Multi-paradigm. So, it can work with multiple types of programming approaches, such as Functional, Object-Oriented, and Visual.

6.1.1 FEATURES OF MATLAB

- MATLAB is a high-level language: MATLAB Supports Object oriented programming. It also supports different types of programming constructs like Control flow statements (IF-ELSE, FOR, WHILE). MATLAB also supports structures like in C programming, Functional programming (writing functions to contain commonly used code and later calling them). It also contains Input / Output statements like disp() and input()

- Interactive graphics: MATLAB has inbuilt graphics to enhance user experience. We can actually visualize whatever data is there in forms of plots and figures. It also supports processing of image and displaying them in 2D or 3D formats. We can visualize and manipulate our data across any of the three dimensions (1D, 2D, and 3D). We can plot the functions and customize them also according to our needs like changing bullet points, line color and displaying/not displaying grid.

- Data access and processing: MATLAB allows accessing of data from external sources like image files (.jpg, .PNG), audio files (.mp), and real-time data from JDBC/ ODBC. We can easily read data from external sources using the inbuilt MATLAB functions like audioread for reading audio files and imread for reading external images.

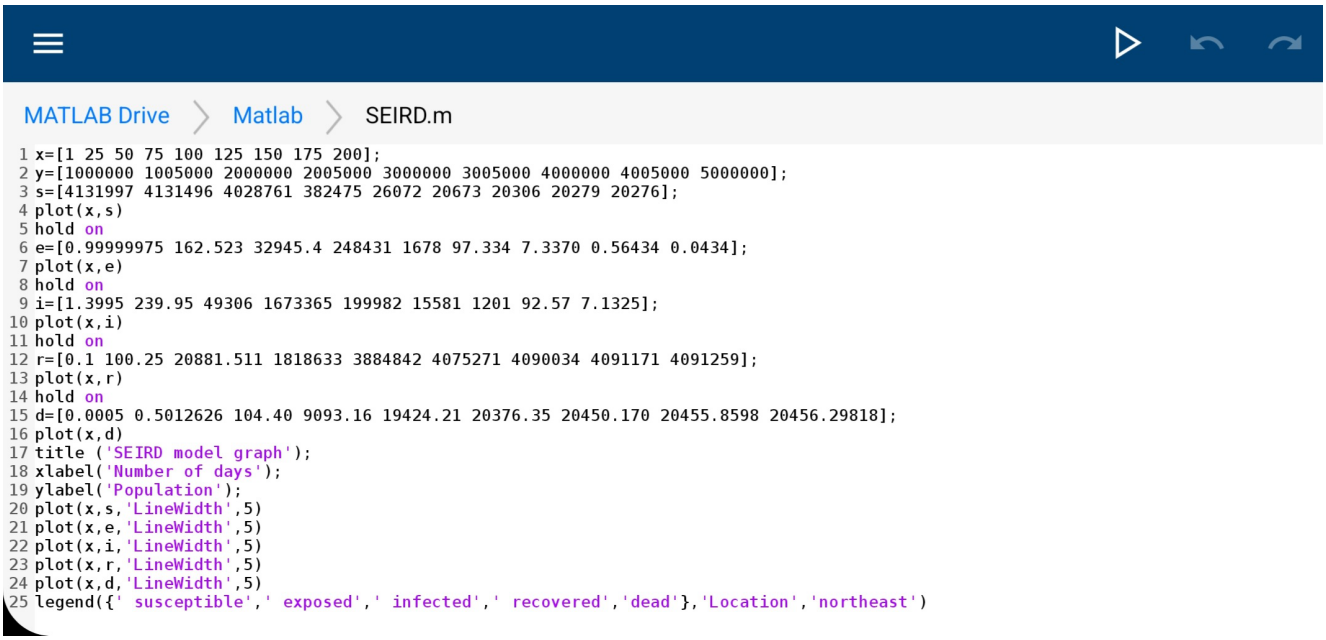
- Interactive environment: MATLAB offers interactive environment by providing a GUI (Graphical user interface) and different types of tools like signal analyses and tuners. MATLAB also has tools for debugging and the development of any software. Importing and exporting files becomes easy in MATLAB through the GUI. We can view the workspace data as we progress in the development of our software and modify it according to our needs.

- MATLAB can interface with different languages: We can write a set of codes (libraries) in languages like PERL and JAVA, and we can call those libraries from within the MATLAB itself. MATLAB also supports ActiveX and .NET libraries.

Chapter 7

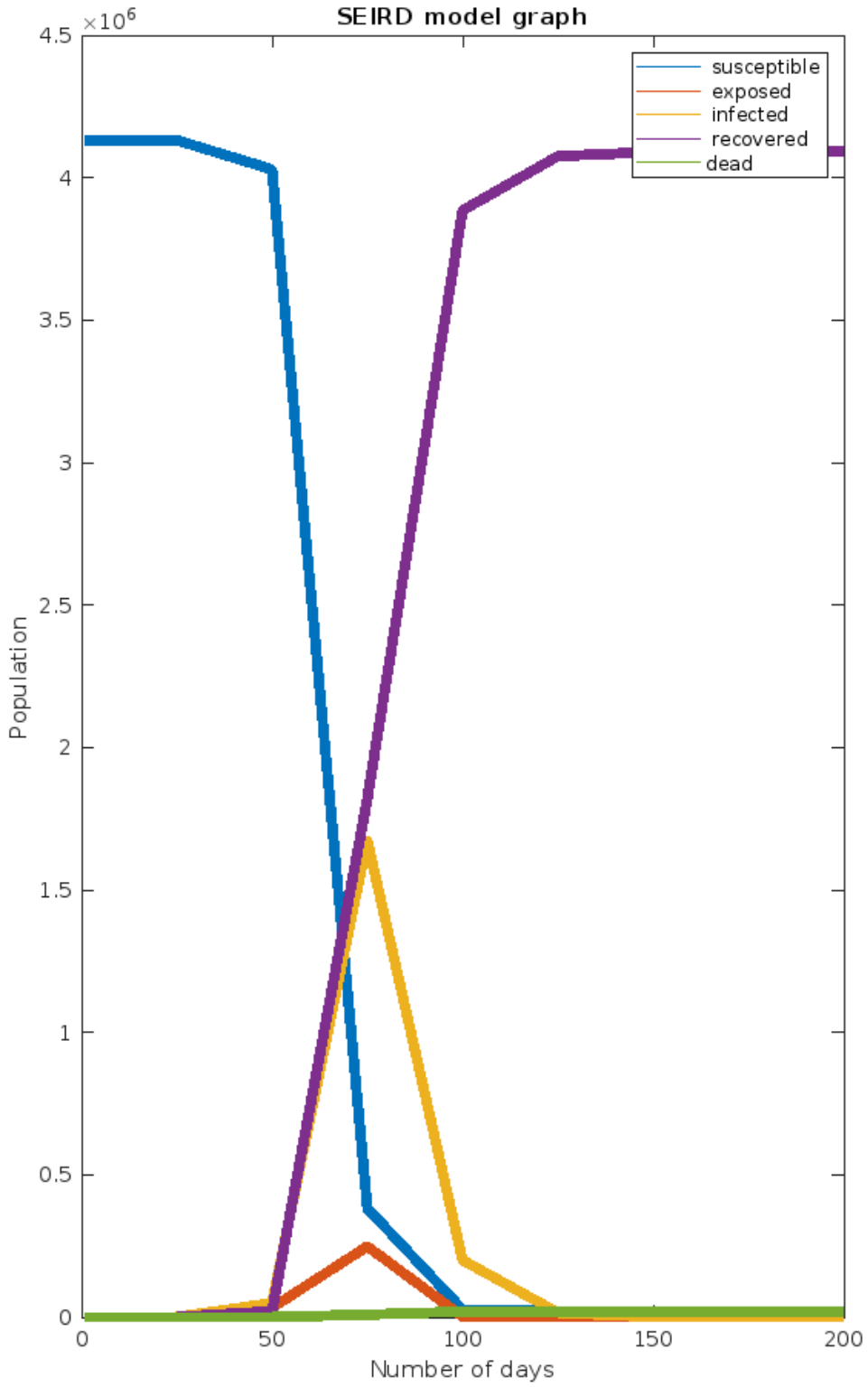
WORKING IN MATLAB

7.1 MATLAB CODE FOR SEIRD MODEL




```
x=[1 25 50 75 100 125 150 175 200];
y=[1000000 1005000 2000000 2005000 3000000 3005000 4000000 4005000 5000000];
s=[4131997 4131496 4028761 382475 26072 20673 20306 20279 20276];
plot(x,s)
hold on
e=[0.99999975 162.523 32945.4 248431 1678 97.334 7.3370 0.56434 0.0434];
plot(x,e)
hold on
i=[1.3995 239.95 49306 1673365 199982 15581 1201 92.57 7.1325];
plot(x,i)
hold on
r=[0.1 100.25 20881.511 1818633 3884842 4075271 4090034 4091171 4091259];
plot(x,r)
hold on
d=[0.0005 0.5012626 104.40 9093.16 19424.21 20376.35 20450.170 20455.8598 20456.29818];
plot(x,d)
title ('SEIRD model graph');
xlabel('Number of days');
ylabel('Population');
plot(x,s,'LineWidth',5)
plot(x,e,'LineWidth',5)
plot(x,i,'LineWidth',5)
plot(x,r,'LineWidth',5)
plot(x,d,'LineWidth',5)
legend({' susceptible',' exposed',' infected',' recovered','dead'},'Location','northeast')
```

7.2 MATLAB OUTPUT GRAPH FOR SEIRD MODEL



Chapter 8

IMPLEMENTATION OF SEIRD MODEL FOR COIMBATORE DISTRICT

8.1 SEIRD JAVA CODE FOR COIMBATORE DISTRICT

```
import java.util.ArrayList;
import java.util.List;

public class model {

    int totalDays = 150; // Days to simulate
    int N = 2787000; // Population
    // SEIR model variables
    int I0 = 1; // Infected initial
    int E0 = 1; // Exposed initial
    double beta = 0.07400;// Infection rate
    double gamma = 0.0180; // Recovery time
    double epsilon = 0.6; //Incubation period
    double alpha = 0.00042;// Death rate

    List<Double> S = new ArrayList<>();
    List<Double> E = new ArrayList<>();
    List<Double> I = new ArrayList<>();
```

```
    List<Double> R = new ArrayList<>();
    List<Double> D = new ArrayList<>();
    List<Double> RR = new ArrayList<>();
    List<Double> IFR = new ArrayList<>();


private void initialvaluemodel(){
    final int R0 = 0;
    final int D0 = 0;
    final int RR0 = 0;
    final int IFR0 = 0;
    final int S0 = N-E0-I0-R0-D0; //Susceptible
        population(Population-Exposed-Infected-Recovered-Death)



        // Adding the initial values
        S.add((double) S0);
        E.add((double) E0);
        I.add((double) I0);
        R.add((double) R0);
        D.add((double) D0);
        RR.add((double) RR0);
        IFR.add((double) IFR0);

        for (int day=1; day<totalDays+1; day++) {
          double[]equation = calculomodel(day);
       S.add(equation[0]);
       E.add(equation[1]);
       I.add(equation[2]);
       R.add(equation[3]);
       D.add(equation[4]);
       RR.add(equation[5]);
       IFR.add(equation[6]);
```

```
   // Printing the values for S, E, I, R, D, RR and IFR day by day
            System.out.println("\n"+"S: "+S.get(day)+" in day: "+day+"\n");
            System.out.println("E: "+E.get(day)+" in day: "+day+"\n");
            System.out.println("I: "+I.get(day)+" in day: "+day+"\n");
            System.out.println("R: "+R.get(day)+" in day: "+day+"\n");
            System.out.println("D: "+D.get(day)+" in day: "+day+"\n");
            System.out.println("RR: "+RR.get(day)+" in day: "+day+"\n");
            System.out.println("IFR: "+IFR.get(day)+" in day: "+day+"\n"+"\n");

        }

       }

       private double[] calculomodel(int day) {
        day = day - 1;
        double dS = (beta * S.get(day) * I.get(day)) / N;
        double newS = S.get(day) - (dS);
        double newE = E.get(day) + (dS - (epsilon * E.get(day)));
        double newI = I.get(day) + ((epsilon * E.get(day)) - ((gamma + alpha)*
            I.get(day)));
        double newR = R.get(day) + (gamma * I.get(day));
        double newD = D.get(day) + (alpha * I.get(day));
        double newRR = RR.get(day) + beta/(gamma + alpha);
        double newIFR = IFR.get(day) + alpha/gamma;
        return new double[] {newS, newE, newI, newR, newD, newRR, newIFR};
    }

     public model(){
         initialvaluemodel();
    }

    public static void main(String[] args) {
        new model();
    }
}
```

8.2 JAVA CODE OUTPUT FOR COIMBATORE DISTRICT

SEIRD JAVA OUTPUT FOR COIMBATORE DISTRICT:

S: 2786997.926000053 in day: 1
E: 0.4739999468963043 in day: 1
I: 1.58158 in day: 1
R: 0.018 in day: 1
D: 4.2E-4 in day: 1
RR: 4.017372421281216 in day: 1
IFR: 0.023333333333333334 in day: 1

S: 2786997.370189108 in day: 5
E: 0.25599804395409764 in day: 5
I: 2.2170408749723767 in day: 5
R: 0.15319736752717605 in day: 5
D: 0.0035746052423007747 in day: 5
RR: 20.08686210640608 in day: 5
IFR: 0.11666666666666667 in day: 5

S: 2786996.462946331 in day: 10
E: 0.3224740973253468 in day: 10
I: 2.8319774648267204 in day: 10
R: 0.37387827992810674 in day: 10
D: 0.008723826531655826 in day: 10
RR: 40.17372421281216 in day: 10
IFR: 0.2333333333333334 in day: 10

S: 2786995.305193391 in day: 15
E: 0.41135187693900555 in day: 15
I: 3.612665601317055 in day: 15
R: 0.655494264034417 in day: 15
D: 0.015294866160803063 in day: 15
RR: 60.26058631921824 in day: 15
IFR: 0.35 in day: 15

S: 2786993.828289246 in day: 20
E: 0.5247462298319862 in day: 20
I: 4.608545313135592 in day: 20
R: 1.0147418994342936 in day: 20
D: 0.023677310986800187 in day: 20
RR: 80.3474484256243 in day: 20
IFR: 0.46666666666666656 in day: 20

S: 2786991.944257919 in day: 25
E: 0.6693990656162401 in day: 25
I: 5.878951598363977 in day: 25
R: 1.4730209285055123 in day: 25
D: 0.034370488331795276 in day: 25
RR: 100.43431053203034 in day: 25
IFR: 0.5833333333333331 in day: 25

S: 2786989.5408705133 in day: 30
E: 0.853926948856177 in day: 30
I: 7.499560590724789 in day: 30
R: 2.057630567057701 in day: 30
D: 0.04801137989801302 in day: 30
RR: 120.52117263843638 in day: 30
IFR: 0.6999999999999997 in day: 30

S: 2786986.474961561 in day: 35
E: 1.0893216537070805 in day: 35
I: 9.566908896629508 in day: 35
R: 2.803395330540173 in day: 35
D: 0.06541255771260404 in day: 35
RR: 140.60803474484243 in day: 35
IFR: 0.8166666666666663 in day: 35

S: 2786982.5639015003 in day: 40
E: 1.389604775426697 in day: 40
I: 12.20414372330849 in day: 40
R: 3.7547394144437827 in day: 40
D: 0.08761058633702161 in day: 40
RR: 160.69489685124847 in day: 40
IFR: 0.9333333333333329 in day: 40

S: 2786977.574718773 in day: 45
E: 1.7726628069586983 in day: 45
I: 15.568357790428704 in day: 45
R: 4.968332862671269 in day: 45
D: 0.115927766795663 in day: 45
RR: 180.78175895765452 in day: 45
IFR: 1.0499999999999998 in day: 45

S: 2786971.2102238657 in day: 50
E: 2.261312331022533 in day: 50
I: 19.859945788936194 in day: 50
R: 6.516467114906589 in day: 50
D: 0.15205089934782046 in day: 50
RR: 200.86862106406056 in day: 50
IFR: 1.166666666666667 in day: 50

S: 2786963.0913091972 in day: 55
E: 2.8846587084639888 in day: 55
I: 25.33453938908409 in day: 55
R: 8.49136094973494 in day: 55
D: 0.19813175549381531 in day: 55
RR: 220.9554831704666 in day: 55
IFR: 1.283333333333334 in day: 55

S: 2786952.7343712742 in day: 60
E: 3.6798290820725663 in day: 60
I: 32.31823117776644 in day: 60
R: 11.010653223978432 in day: 60
D: 0.2569152418928301 in day: 60
RR: 241.04234527687265 in day: 60
IFR: 1.4000000000000012 in day: 60

S: 2786939.5225114725 in day: 65
E: 4.694182739346143 in day: 65
I: 41.22699345974588 in day: 65
R: 14.224409441280017 in day: 65
D: 0.33190288696320047 in day: 65
RR: 261.1292073832787 in day: 65
IFR: 1.5166666666666684 in day: 65

S: 2786922.6688020173 in day: 70
E: 5.988130194099011 in day: 70
I: 52.591447148682846 in day: 70
R: 18.324059256392125 in day: 70
D: 0.4275613826491497 in day: 70
RR: 281.21606948968474 in day: 70
IFR: 1.6333333333333355 in day: 70

S: 2786901.1694324077 in day: 75
E: 7.638728413250931 in day: 75
I: 67.08845370844921 in day: 75
R: 23.553796876231846 in day: 75

D: 0.5495885937787433 in day: 75
RR: 301.3029315960908 in day: 75
IFR: 1.7500000000000027 in day: 75

S: 2786873.7439508704 in day: 80
E: 9.744265533029928 in day: 80
I: 85.58140797643962 in day: 80
R: 30.225122755211547 in day: 80
D: 0.7052528642882694 in day: 80
RR: 321.38979370249683 in day: 80
IFR: 1.8666666666666698 in day: 80

S: 2786838.7590502542 in day: 85
E: 12.430106836969491 in day: 85
I: 109.17162544594764 in day: 85
R: 38.73539165680027 in day: 85
D: 0.9038258053253396 in day: 85
RR: 341.4766558089029 in day: 85
IFR: 1.983333333333337 in day: 85

S: 2786794.1313732504 in day: 90
E: 15.856148062581395 in day: 90
I: 139.26387430784777 in day: 90
R: 49.591470076832366 in day: 90
D: 1.1571343017927553 in day: 90
RR: 361.5635179153089 in day: 90
IFR: 2.100000000000004 in day: 90

S: 2786737.2035714053 in day: 95
E: 20.226316487758943 in day: 95
I: 177.64993836663703 in day: 95
R: 63.43990919243547 in day: 95
D: 1.4802645478234944 in day: 95
RR: 381.65038002171497 in day: 95
IFR: 2.2166666666666712 in day: 95

S: 2786664.586274363 in day: 100
E: 25.80068001519417 in day: 100
I: 226.61516000387695 in day: 100
R: 81.10542568475634 in day: 100
D: 1.892459932644315 in day: 100
RR: 401.737242128121 in day: 100
IFR: 2.3333333333333384 in day: 100

S: 2786571.9566198587 in day: 105
E: 32.91087622297522 in day: 105
I: 289.0742633262352 in day: 105
R: 103.63997451957832 in day: 105
D: 2.4182660721234943 in day: 105
RR: 421.82410423452706 in day: 105
IFR: 2.4500000000000055 in day: 105

S: 2786453.8014476243 in day: 110
E: 41.979765252510184 in day: 110
I: 368.7444726526863 in day: 110
R: 132.38532358691813 in day: 110
D: 3.0889908836947573 in day: 110
RR: 441.9109663409331 in day: 110
IFR: 2.5666666666666726 in day: 110

S: 2786303.0900296154 in day: 115
E: 53.546452480534036 in day: 115
I: 470.3661156921188 in day: 115
R: 169.0528360377001 in day: 115
D: 3.944566174213003 in day: 115
RR: 461.99782844733915 in day: 115
IFR: 2.68333333333334 in day: 115

S: 2786110.857118061 in day: 120
E: 68.29813129781515 in day: 120
I: 599.9836522211169 in day: 120
R: 215.82517760923352 in day: 120
D: 5.035920810882116 in day: 120
RR: 482.0846905537452 in day: 120
IFR: 2.800000000000007 in day: 120

S: 2785865.67192379 in day: 125
E: 87.11057740446655 in day: 125
I: 765.303543125731 in day: 125
R: 275.4859501751621 in day: 125
D: 6.428005504087116 in day: 125
RR: 502.17155266015124 in day: 125
IFR: 2.916666666666674 in day: 125

S: 2785552.9621238187 in day: 130
E: 111.09960049950243 in day: 130
I: 976.1497481253755 in day: 130
R: 351.58488034782664 in day: 130
D: 8.203647208115955 in day: 130
RR: 522.2584147665574 in day: 130
IFR: 3.033333333333341 in day: 130

S: 2785154.1538187265 in day: 135
E: 141.68634558362965 in day: 135
I: 1245.0431249800552 in day: 135
R: 448.6482515074271 in day: 135
D: 10.468459201839966 in day: 135
RR: 542.3452768729637 in day: 135
IFR: 3.1500000000000083 in day: 135

S: 2784645.5781392492 in day: 140
E: 180.6800534317919 in day: 140
I: 1587.9378459558475 in day: 140
R: 572.4468677815175 in day: 140
D: 13.357093581568742 in day: 140
RR: 562.43213897937 in day: 140
IFR: 3.2666666666666755 in day: 140

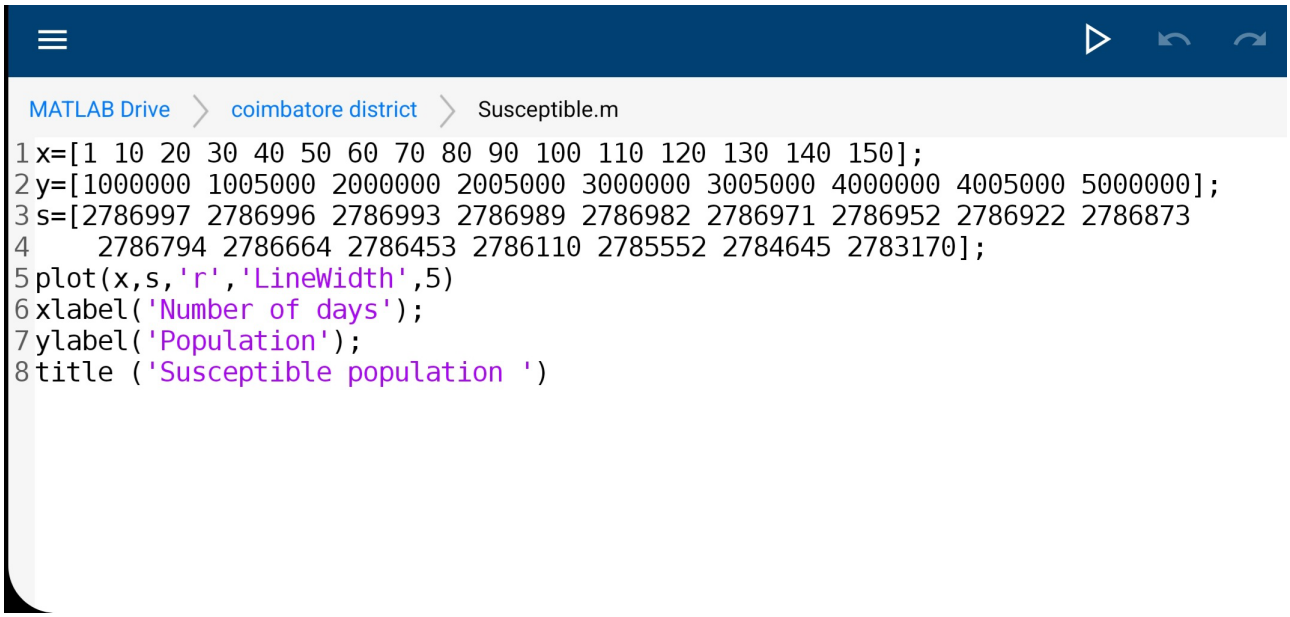
S: 2783997.0825058976 in day: 145
E: 230.38275533194602 in day: 145
I: 2025.1564281317637 in day: 145
R: 730.337111372991 in day: 145
D: 17.041199265369794 in day: 145
RR: 582.5190010857764 in day: 145
IFR: 3.3833333333333426 in day: 145

S: 2783170.2689053845 in day: 150
E: 293.72140135506254 in day: 150
I: 2582.5753905906636 in day: 150
R: 931.6947583086866 in day: 150
D: 21.73954436053603 in day: 150
RR: 602.6058631921827 in day: 150
IFR: 3.5000000000000098 in day: 150

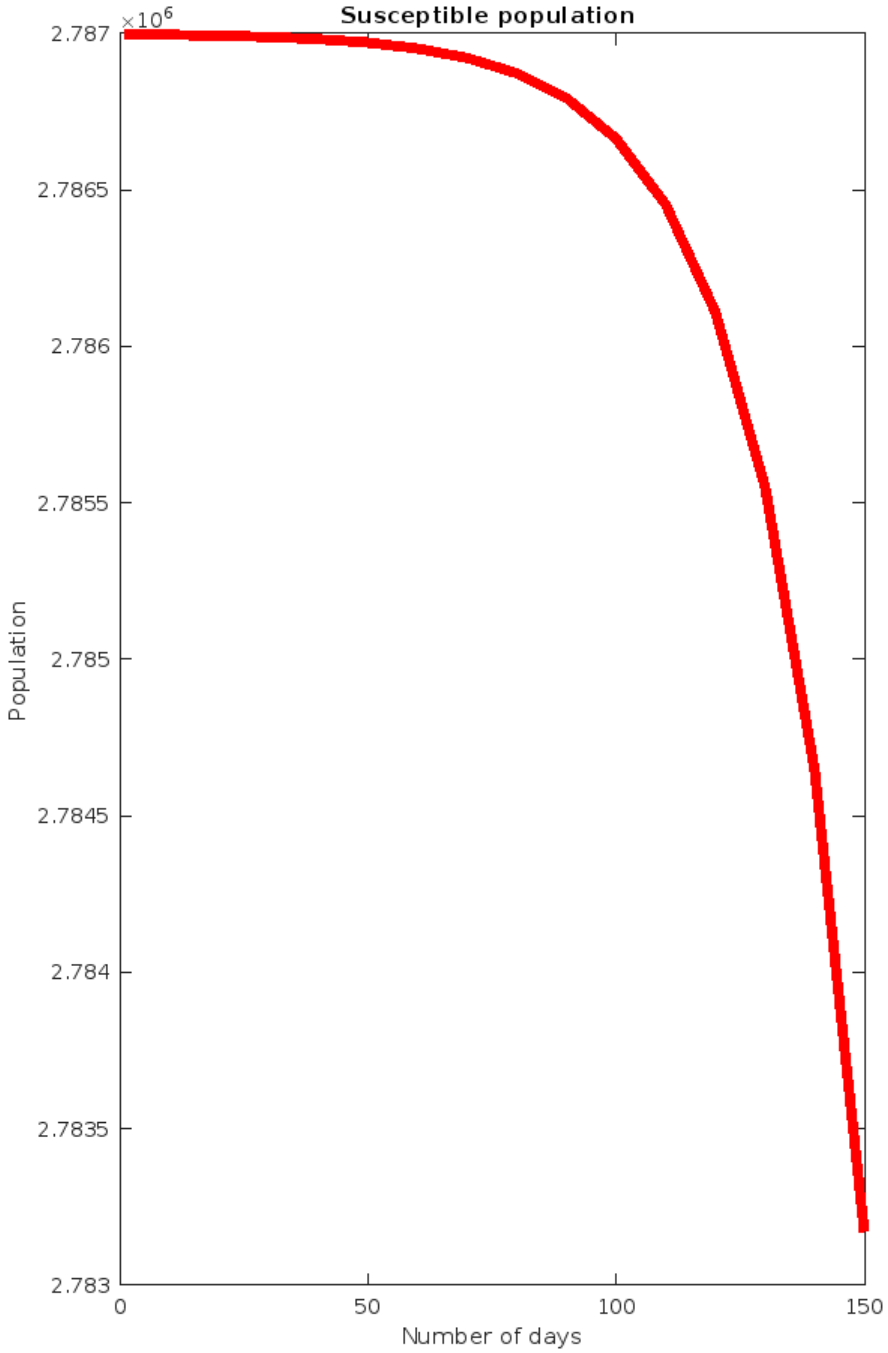
Chapter 9

MATLAB CODE AND GRAPH FOR COIMBATORE DISTRICT

SUSCEPTIBLE POPULATION

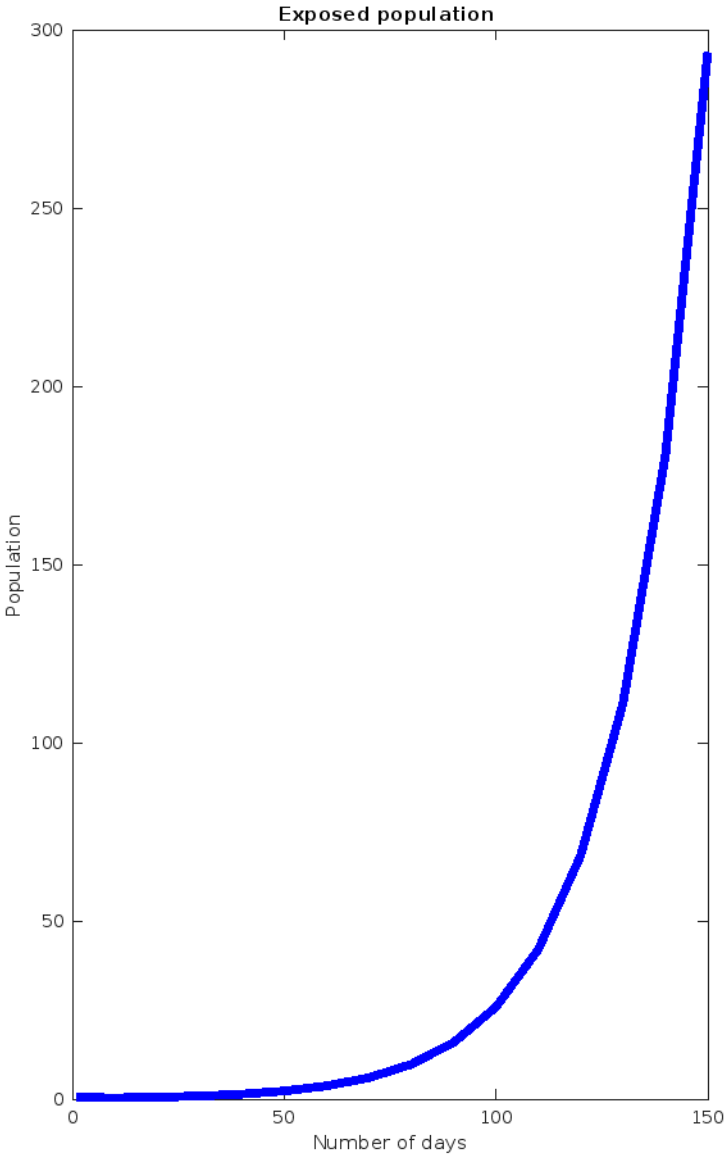



```
x=[1 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150];
y=[1000000 1005000 2000000 2005000 3000000 3005000 4000000 4005000 5000000];
s=[2786997 2786996 2786993 2786989 2786982 2786971 2786952 2786922 2786873
    2786794 2786664 2786453 2786110 2785552 2784645 2783170];
plot(x,s,'r','LineWidth',5)
xlabel('Number of days');
ylabel('Population');
title ('Susceptible population ')
```


Susceptible population
×10^6
2.787
2.7865
2.786
2.7855
2.785
2.7845
2.784
2.7835
2.783
Population
0
50
100
150
Number of days

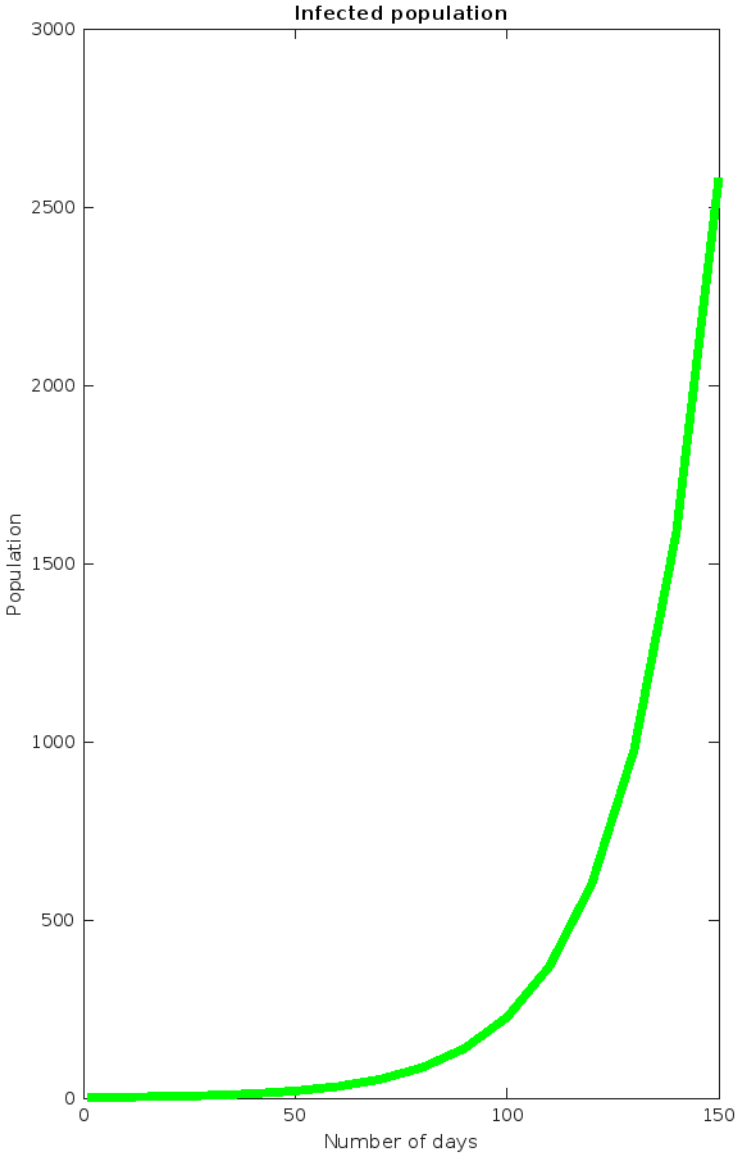
MATLAB Drive > coimbatore district > Exposed.m

```
e=[0.4739999 0.3224740 0.5247462 0.8539269 1.3896047754 2.2613123 3.679829
    5.98813019 9.7442655 15.856148 25.800068 41.979765 68.298131 111.099600
    180.680053 293.721401];
x=[1 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150];
y=[1000000 1005000 2000000 2005000 3000000 3005000 4000000 4005000 5000000];
plot(x,e,'b','LineWidth',5)
xlabel('Number of days');
ylabel('Population');
title ('Exposed population ')
```



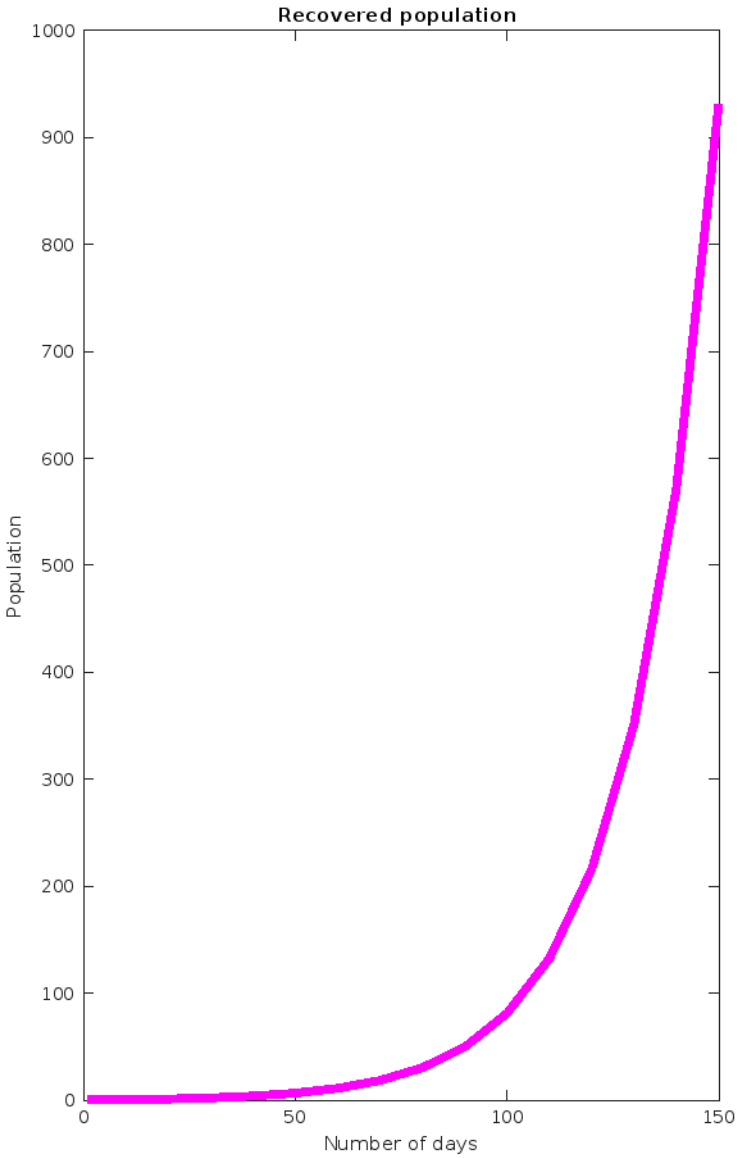
MATLAB Drive > coimbatore district > Infected.m

```
i=[1.58158 2.831977 4.608545 7.499560 12.204143 19.859945 32.3182311
    52.591447 85.581407 139.26387 226.61516 368.74447 599.983652 976.149748
    1587.93784 2582.575];
x=[1 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150];
y=[1000000 1005000 2000000 2005000 3000000 3005000 4000000 4005000 5000000];
plot(x,i,'g','LineWidth',5)
title('Infected population')
xlabel('Number of days');
ylabel('Population');
```



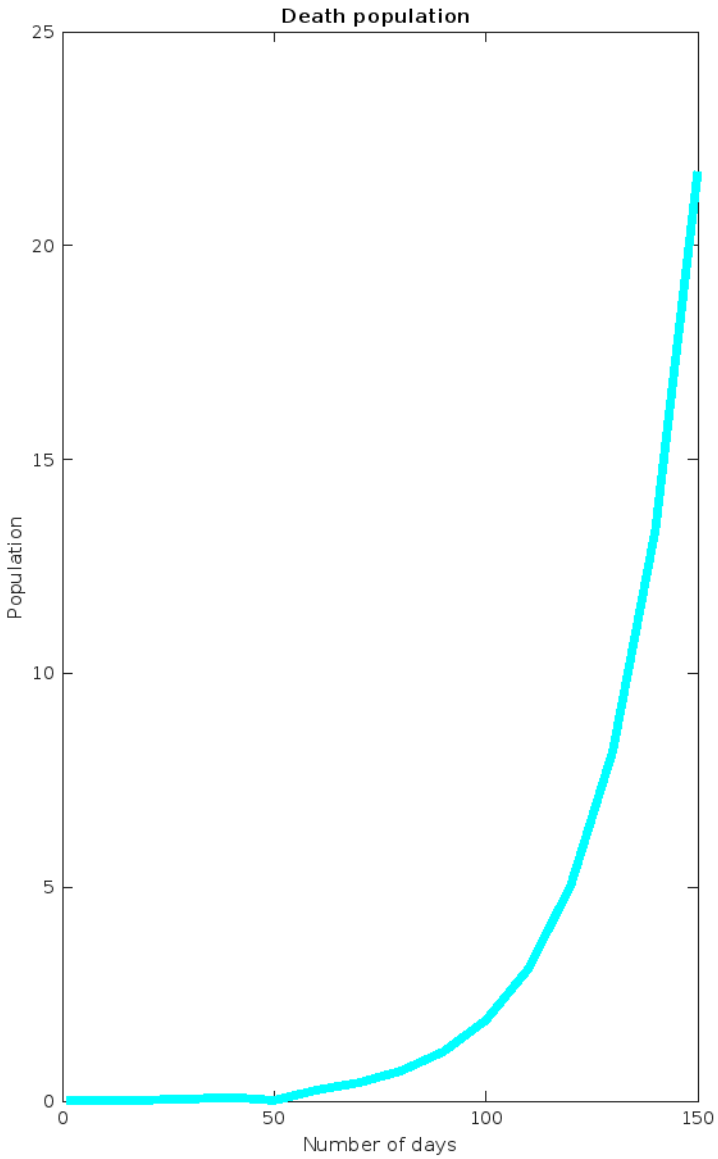
MATLAB Drive > coimbatore district > Recovered.m

```
r=[0.018 0.373878 1.01474 2.057630 3.754739 6.5164671 11.0106532
    18.3240592 30.225122 49.59147 81.105425 132.385323 215.825177 351.58488
    572.4468677 931.69476];
x=[1 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150];
y=[1000000 1005000 2000000 2005000 3000000 3005000 4000000 4005000 5000000];
plot(x,r,'m','LineWidth', 5)
xlabel('Number of days');
ylabel('Population');
title ('Recovered population ')
```



MATLAB Drive > coimbatore district > Death.m

```
d=[0.00042 0.008723 0.023677 0.048011 0.0876105 0.015205089 0.25691524
    0.42756138 0.705252864 1.15713430 1.892459932 3.08899088 5.03592081
    8.2036472 13.357093 21.7395443];
y=[1000000 1005000 2000000 2005000 3000000 3005000 4000000 4005000 5000000];
x=[1 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150];
plot(x,d,'c','LineWidth',5)
xlabel('Number of days');
ylabel('Population');
title('Death population ')
```



Chapter 10

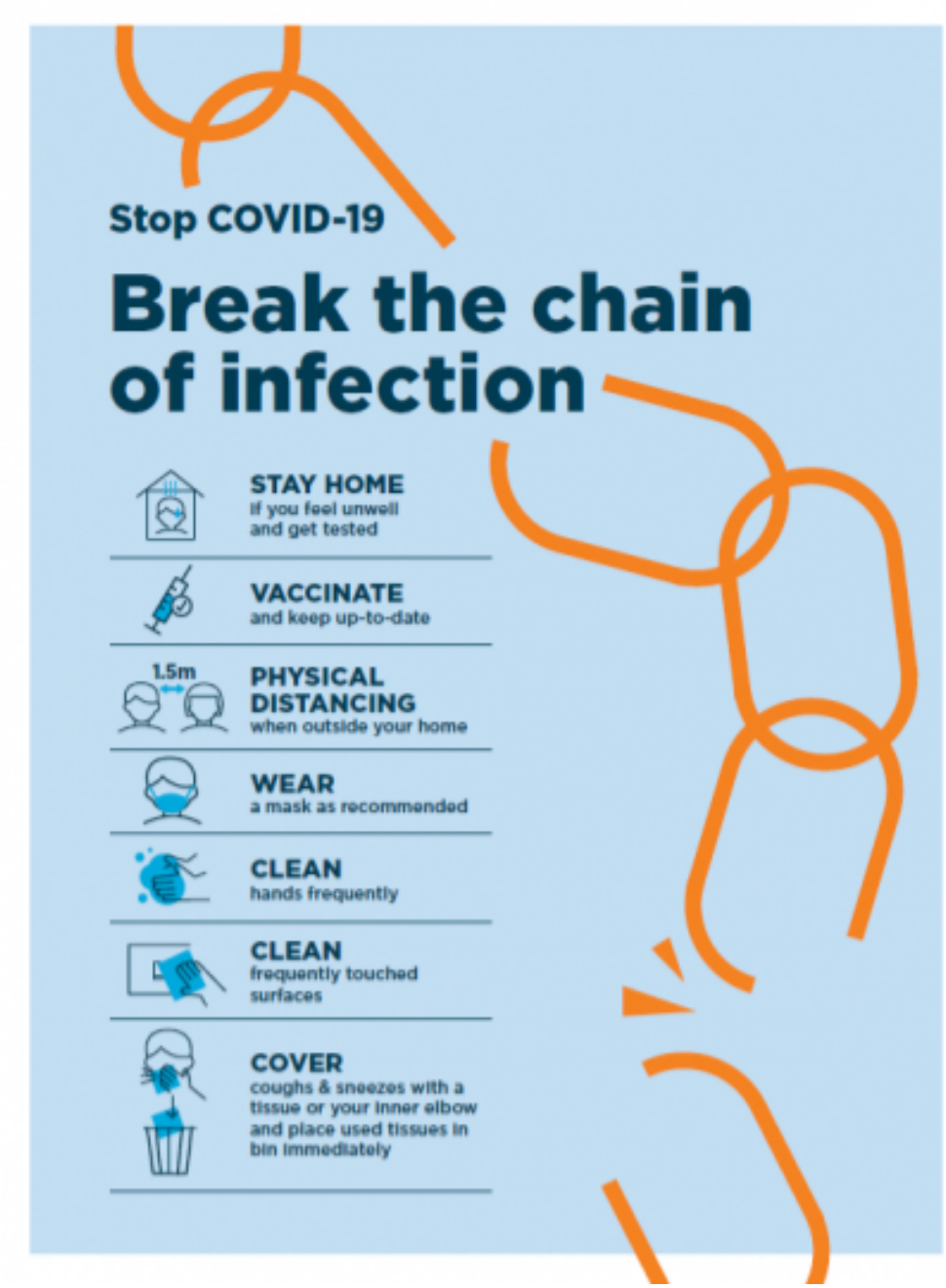
CONCLUSION

Mathematical modelling theories are effective tools to deal with the time evolution and patterns of disease outbreaks. They provide us with useful predictions in the context of the impact of intervention in decreasing the number of infected-susceptible incidence rates.

Thus, our SEIRD model considered in our project provides a theoretical framework to investigate the spread of the COVID-19 virus within communities. The model can give insights into the time evolution of the spread of the virus that the data alone does not. In this context, it can be applied to communities, given reliable data are available. Its power also lies to the fact that, as new data are added to the model, it is easy to adjust its parameters and provide with best-fit curves between the data and the predictions from the model. It is in this context then, it can provide with estimates of the number of likely deaths in the future and time scales for decline in the number of infections in communities. Our results show that the SEIRD model is more suitable to predict the epidemic trend due to the spread of the disease as it can accommodate surges and be adjusted to the recorded data.

By comparing the published data with predictions, it is possible to predict the success of government interventions. The considered data of coimbatore district are taken in between February and July, 2020 that contains the datasets before and during the implementation of strict and control measures. Our analysis also confirms the success and failures in some countries in the control measures taken, because by comparing the recorded data with the data from our modelling approaches, we deduce that the spread of covid-19 can be under control in all communities considered, if proper restrictions and strong policies are implemented to control the infection rates early from the spread of the disease.

Countries around the world have taken steps to decrease the number of infected citizens, such as lock-down measures, awareness programs promoted via media, hand sanitization campaigns, etc. to slow down the transmission of the disease. Additional measures, including early detection approaches and isolation of susceptible individuals to avoid mixing them with no-symptoms and self-quarantine individuals, traffic restrictions, and medical treatment have shown they can help to prevent the increase in the number of infected individuals. Strong lock-down policies can be implemented, in different areas, if possible. In line with this, necessary public health policies have to be implemented in countries with high rates of COVID-19 cases as early as possible to control its spread.



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[2] What is coronavirus? (n.d.). Johns Hopkins Medicine, based in Baltimore, Maryland. *https://www.hopkinsmedicine.org/health/conditionsand-diseases/coronavirus*

[3] How scientists predict how many people will get COVID-19. (2020, April 1). WebMD. *https://www.webmd.com/lung/news/20200401/howscientists-predict-how-many-people-will-get-covid-19*

[4] *https://www.who.int/emergencies/diseases/novel-coronavirus-2019/*

[5] *https://onlinelibrary.wiley.com/doi/full/10.1111/irv.12915*

[6] *https://www.geeksforgeeks.org/overview-of-sir-epidemic-model-for-corona-virus-outbreak-prediction/*

[7] *https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7505224/*

[8] *https://www.geeksforgeeks.org/overview-of-sir-epidemic-model-for-corona-virus-outbreak-prediction/*

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[10] *https://towardsdatascience.com/infectious-disease-modelling-beyond-the-basic-sir-model-216369c584c4*