AGENT-BASED SIMULATION MODEL OF COVID-19 EPIDEMIC TO ANALYZE ITS INFECTION RISKS IN NATIONAL CENTER FOR MENTAL HEALTH (NCMH) USING THE GAMA PLATFORM

by

Lyka Raquel C. Lim

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This is to certify that this Special Problem entitled **"Agent-Based Simulation Model of COVID-19 Epidemic to analyze its infection risks in National Center for Mental Health (NCMH) using the GAMA Platform"**, prepared and submitted by **Lyka Raquel C. Lim** to fulfill part of the requirements for the degree of **Bachelor of Science in Computer Science**, was successfully defended and approved on June 15, 2023.

JOEL M. ADDAWE, PH.D.
Special Problem Adviser

The Department of Mathematics and Computer Science endorses the acceptance of this Special Problem as partial fulfillment of the requirements for the degree of Bachelor of Science in Computer Science .

GILBERT R. PERALTA, DR.RER.NAT.
Chair
Department of Mathematics and
Computer Science

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Abstract

Agent-Based Simulation Model of COVID-19 Epidemic to analyze its infection risks in National Center for Mental Health (NCMH) using the GAMA Platform

Lyka Raquel C. Lim
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Adviser:
Joel M. Addawe, Ph.D.

The coronavirus disease (COVID-19) was rapidly spreading and now poses a threat to almost every nation in the world. In order to lessen the economic effects of the whole or partial closure of enterprises, colleges, stores, and other facilities, countries opted to return to a new normal despite some countries approach the peak of infection under various circumstances. In this study, using mathematical models to evaluate the risk of COVID-19 transmission in different institutions is a significant tool for assisting authorities in making wise decisions. In this study, we simulate the National Center for Mental Health's (NCMH) COVID-19 possible outbreak among patients and healthcare professionals using an agent-based model. Simulated agents in the model decide what to do depending on predetermined rules. The geographical patterns and conditions that agents use to interact are incorporated the transmission process. To show how well the recommended model works, several hypothetical situations were examined. The experimental findings demonstrate that the simulations offer crucial data for formulating plans to reduce the danger of COVID-19 spread within the institution. The model could aid public authorities in making judgments due to its fine-grained resolution, open-source nature, and wide range of attributes. Experiments showed that applying 14-day lockdown minimized the number of infected people by 2.17%, reduction by 2.82% when isolation areas for infected agents are provided and by at most 10% reduction with the combination of both the scheduled lockdown and provision of isolation areas.

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Chapter 1

Introduction

1.1 Background of the Study

COVID-19, a virus, swept around the world in 2020. This is classified as a contagious diseases since the virus can be spread from one person to another via various means such as coughing, direct touch, and so on [13]. Since we are in a middle of a pandemic, studying the possible infection rate has become our interest, knowing that an infected individual may or may not present symptoms of the COVID-19 virus. As of April 2020, the total number of confirmed cases is 896,475, and the number of deaths is 45,525 [18]. Understanding the mechanisms of how the COVID-19 virus spreads will provide knowledge on the possible scale of the epidemic, controls and preventive measures needed to reduce the risks of transmission, and the factors that affect the transmission process.

Older SARS-CoV-2 patients have had the most severe outcomes, including the highest rates of death, while infected younger people, notably children aged 1-18 years, are just modestly ill compared to elderly patients [8]. While the age-dependent pattern of sickness severity is established, the roles of various ages in spreading the virus are less evident. Recently, evidence has emerged that infection susceptibility generally rises with age [30]. But, this doesn't mean that the elderly individuals are the main reason why the spread of COVID 19 is happening because according to studies particularly in Europe, younger persons, specifically those under the age of 35, have the highest probability of infection [23].

People all across the world are currently being affected by the COVID-19 pandemic. While there was still no specific cure for this virus, current management focused on stopping the spread of the virus and giving sick patients supportive care without fundamental therapeutic procedures [29]. Thus, rapid spread of the SARS-CoV-2 epidemic necessitated extraordinary worldwide control measures. Travel bans, varied degrees of mobility limitations, and countrywide lockdowns. Since March 9, 2020, travelers from any nation have been prohibited to enter Israel unless they can demonstrate their ability to remain in home isolation for 14 days. Daycare and schools were closed beginning March 16, and work was reduced to less than one-third of its normal capacity. On March 26, non-essential travel was limited to 100 meters from home, and three different lockdowns were imposed in most locations of Israel to reduce crowding caused by holiday celebrations [28]. These massive measures have resulted in a sharp decline in transmission, indicating that an individual's mobility affects the risk of COVID-19 transmission. To improve the understanding of the virus transmission, the researcher will use an agent-based model to simulate the infection risks of COVID 19 in a facility with the aim of comparing the result when moderation applied is a scheduled lockdown, providing isolation area for infected agents, or the combination of both.

Mathematical models and traditional methods using experimental and statistical data are used to understand complex systems like disease transmission processes, but for infectious diseases like COVID-19, traditional methods are not appropriate. A broad-based test may be impractical and unethical, and it entails gathering data that is not as accurate as reputable statistical studies [14]. Thus, mathematical modeling is acknowledged and commonly utilized to gather information regarding disease transmission and spread mechanisms. It saves more time and resources compared to experimental approaches [14]. Also, by using this model, the researcher would be able to compare several possible outcomes while considering various hypothetical situations that are impossible to examine under realistic conditions.

One example of a mathematical model is a scheme known as agent-based modeling, which is used to simulate complex models with the help of agents [9]. These agents are programmed individuals who interact with each other under behaviors that are described by simple rules [15]. These rules imitate the behaviors of real actors interacting in an environment. Agent-based modeling describes behaviors in different areas, such as supply chains, transportation, and more.

To assess the COVID-19 virus transmission in facilities and assist authorities in making informed decisions, an agent-based model will be used. In this experiment using this model, the agents are determined and interact with each other under different rules and moderation. Here, the agents interact in a given environmental space known as a virtual map. This virtual map will depict an open facility in a Philippine context, specifically the National Center for Mental Health in Mandaluyong, Philippines in order to evaluate the effects of human interactions on virus transmission. Because of the nature of transmission, the number of persons present at a particular site and their behaviors has a direct impact on the likelihood of infection. The model will be tested using different conditions and scenarios to obtain conditions that need to be imposed to reduce the transmission risks.

The following are the steps in a general agent-based modeling approach. First, a set of agents is created. During this step, agents are configured in a given position or state. The agents are then chosen at random or in a specific order. A set of rules is applied to this specific agent in order to change its position. These principles take into account the relationship between conditions imposed by other agents (particular agents) or local impacts (neighbor agents). This process is repeated until a predetermined stop criterion is met. [10]

1.2 Statement of the Problem

Mathematical models will help us understand the behavior of the disease. The model will consider the human population inside the facility. The human population is divided into exposed, susceptible, infected, recovered, or dead due to the virus. When a right model is found and implemented, different moderation will be executed to be able to analyze the effects it makes in the population and the difference it gives compared to other moderation executed. After the models are already working, real data were collected with regards to the problem being modeled.

Real data were collected from the National Center for Mental Health. The NCMH currently has 451 nurses handling an average daily number of 3,500 in-patients in 2020, a total of 3951 people [7]. In this study, we will round off the population into 4000 where 5 of them will be considered initially infected. The agent's Probability of Infection ranges from 30% - 80% since most agents are mentally unstable and most likely can't properly follow preventive protocols. For the sake of studying the behavior of the transmission, PRI is exaggerated while for the Recovery Rate, on average about 98.2% of known COVID-19 patients in the U.S. survive [4]. Thus for this study, we will use 80% recovery probability for every infected agents while the remaining 20% is the probability that the agent dies due to the virus.

Worldwide lockdown, quarantine, and some restrictions have been imposed due to COVID-19's daily rising cases and fatalities. The COVID-19 pandemic was observed to be prevented, and the lockdown, one of the social isolation restrictions, demonstrated that the propagation of the virus can be greatly slowed down by this preventive restriction [2]. With this, the researcher also wanted to analyze the effects of implementing a scheduled lockdown and an isolation area for infected agents and analyze its result in the transmission risk of the virus inside the facility.

1.3 Objective of the Study

In this experiment, the researcher hope to model the following general and specific objectives:

1.3.1 General Objective of the Study

The general objective of this study is to model the interactions in the National Center for Mental Health in order to develop predictions about disease spread based on the moderation that will be implemented and demonstrate the model's properties and the outcomes that it can offer. The procedures of the NCMH facility setting will be carried out using QGIS for structuring the shape files that will be used and GAMA Platform for the simulation of the experiment, with an emphasis on the different moderation that could be imposed to reduce the transmission of the virus. GAMA is an open-source modeling and simulation development environment for building spatially explicit agent-based simulations. It has been developed with a very general approach and can be used in any application domain. [25].

With that, it aims to show that the experimental results of this model will provide important information for developing methods to reduce COVID-19 transmission hazards within the facility.

1.3.2 Specific Objective of the Study

In this experiment, the researcher hope to model a COVID-19 transmission inside the facility. Given the equations and variables, this study will find and execute the following specific objectives:

1. To set up the virtual environment where the experiment would take place, a shape-file of road networks and buildings in the NCMH will be made to execute the experiment. The agents will freely move and interact in this virtual environment.

2. To consider five types of agents namely, the susceptible agents, the exposed agents, the infected agents, the recovered agents, and the dead agents.

3. To position the initial placement of all the agents in the experiment. Initially, agents will be placed randomly on one of the buildings in the virtual environment.

4. To assign a Probability of Infection where this simplifies the factors affecting the transmission of diseases from one individual to another.

5. To be able to determine the movement of each agent and assign a target location for each within the facility.

6. To identify how each agent could get exposed, infected, recover, or die by applying probabilistic tests.

7. To implement different moderation in order to analyze the overall behavior of each agents and its effect on minimizing the virus transmission risk.

8. To be able to implement a scheduled lockdown and isolation area for the agents and add a mobility restrictions to each agents based on the moderation being implemented.

9. To be able to compare the result of each moderation and analyze the impact these moderation could bring in minimizing the virus transmission risk inside the facility.

1.4 Significance of the Study

Given the mathematical model and the data outcome of this experiment, we can compute and simulate the behavior of the disease spread as well as its possible effect on the community. This study will focus on providing insights into the possible behavior of COVID 19 transmission, specifically inside a closed facility.

Through this experiment, the community will further realize promoting different moderation, specifically implementing a lockdown and isolation area for infected agents, as a preventive measure against COVID-19. People, other medical institutions, and facilities may also consider implementing these moderation to minimize the virus transmission risk.

Moreover, the analysis presented in this study will convey valuable information for future research exploring not just the Coronavirus Disease but other diseases that are infectious.

1.5 Scope and Limitation

Out of all the people residing inside the National Center for Mental Health, 4000 agents were used as a sample in conducting the experiment with 5 being initially infected. This study limits its coverage on the agents staying inside the National Center for Mental Health only. Its main purpose is to identify the virus transmission risk inside the facility and the outcome when different moderation were to be applied. This study considers every aspect of the agent's information that has an impact on their infection probability such as their positions, mobility, exposure time, target locations, interaction with other agents, etc. Each of the agents are given different probability of infection and target locations at each iteration but has the same chances of recovery and death due to the virus. This study focuses on the outcome of the simulation when implementing different moderation and analyzes its long term effect to minimize the virus transmission risk inside the facility.

Chapter 2

Review of Related Literature

This chapter presents the compilation of studies, which are conducted here and in other countries, in which the present study proposes some bearing of similarity. Early in December 2019, Wuhan City, Hubei Province, China had an outbreak of the coronavirus illness 2019 (COVID-19), which was brought on by a brand-new severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2). The epidemic was deemed a Public Health Emergency of International Concern by the World Health Organization on January 30, 2020. 49,053 laboratory-confirmed deaths and 1,381 total deaths have been reported as of February 14, 2020, worldwide. Many countries have implemented a range of control measures due to the perceived risk of contracting sickness [12]. As of April 2020, the total number of confirmed cases is 896,475, and the number of deaths is 45,525 [18]. Understanding the mechanisms of how the COVID-19 virus spreads will provide knowledge on the possible scale of the epidemic, controls and preventive measures needed to reduce the risks of transmission, and the factors that affect the transmission process. Mathematical models and traditional methods using experimental and statistical data are used to understand complex systems like disease transmission processes, but for infectious diseases like COVID-19, traditional methods are not appropriate. A wide-range test may be impossible and unethical, and it includes garnering information that is not accurate enough as reliable statistical studies [14]. Thus, mathematical modeling is recognized and has been widely used to obtain information about the mechanisms of the transmission and spread of diseases. It saves more time and resources compared to experimental approaches [14]. Also, by using this model, the researchers would be able to compare several possible outcomes while considering various hypothetical situations that are impossible to examine under realistic conditions.

2.1 Agent-Based model as a mathematical model

One example of a mathematical model is a scheme known as agent-based modeling, which is used to simulate complex models with the help of agents [9]. These agents are programmed individuals who interact with each other under behaviors that are described by simple rules [15]. These rules imitate the behaviors of real actors interacting in an environment. Agent-based modeling describes behaviors in different areas, such as supply chains, transportation, and more.

An example of an agent-based model is a Fire Spreading Model that simulates fire movement in a forest fire. In reality, A fire does not spread based on deterministic principles. Various elements may affect fire transmissions from one tree to another, such as the wind, type of wood, and distance between trees. In agent-based modeling, the mechanism can be simplified using probability when many factors affect a process, like the factors affecting the transmission of fire in trees, and it can be used as a parameter in the model. A probability of spread p is the parameter, an integer, that will control how frequently the fire spreads from one tree to another. The effect of using p on fire spreading can be explored by experimenting with different values of p. Comparing the results using a different probability of spread shows that it produces different effects on the overall spread of fire [26].

Another example of an agent-based model is the Schelling Segregation model proposed by Thomas Schelling in 1970. The model explains why people with different ethnic origins segregate themselves geographically and is an agent-based model that shows how a person's feelings for their neighbors can cause segregation. The model is especially helpful in studies of ethnic group residential segregation because agents represent homeowners who move into the city. According to a research of high-resolution ethnic residential patterns in Israeli cities, reality is more complex than this straightforward integration-segregation dichotomy suggests. Some neighborhoods are ethnically homogeneous, while others include varying percentages of residents from both groups. In this work, the researchers evaluated the Schelling model's ability to reproduce such patterns and looked into the dynamics of the model's reliance on group-specific tolerance thresholds and the ratio of the sizes of the two groups. In a novel model pattern that we present, some members of one group segregate while other members remain integrated with the second group [20].

The spread of a disease, the total number of infected, the length of an epidemic, and estimation of other epidemiological metrics like the reproductive number are all things that an agent-based model attempt to predict. Such simulations can demonstrate the potential impact of various public health initiatives on the course of an epidemic using a compartmental modeling [11].

2.2 Compartmental Modeling

A model which classifies the individuals in a population into compartments depending on their status with regard to the infection under study. Compartmental modeling is a versatile modeling approach and are frequently used in the modeling of infectious diseases using mathematics. Labeled compartments are used to categorize the population, such as S, I, R, or D (Susceptible, Infected, Recovered, or Dead) where moving between compartments is possible [11]. The number of people who are susceptible to the disease, or who are not (yet) affected at time t, is denoted by S(t). I(t) represents the number of infected people who are presumed to be contagious and capable of spreading the illness through contact with susceptible agents at time t. R(t) represents the number of people who have been infected and then eliminated from the risk of re-infection or illness spread at time t while D(t) represent the number of people who died due to the virus at time t [6]. Some of the compartmental models are:

2.2.1 Susceptible-Infected (SI) Model

Of all the disease models, the SI model is the most straightforward. People enter the simulation at birth without any immunity, making them susceptible. Without treatment, those who become infected remain contagious for the rest of their lives and continue to interact with those who are vulnerable.

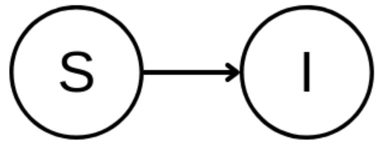

Figure 2.1: Flowchart for the Susceptible-Infected Model

The Susceptible-Infected (SI) Model divides the population into two groups: those who are Susceptible or vulnerable to contracting the disease (S) and those who are infected and may disseminate it to others (I). Once a susceptible is infected, he or she joins the infected class, which reduces the number of the susceptible class and grows the infected class [24]. Once infected, a person cannot recover and is permanently classified as being in the I class [1]. Additionally, we assume that the illness outbreak will end quickly compared to the normal person's lifespan, eliminating the possibility of death [22]. As a result, this model can be used to describe diseases like herpes (HSV-1 or HSV-2) caused by the Herpesviridae virus, for which there is no cure and for which the condition spreads quickly [24].

2.2.2 Susceptible-Infected-Susceptible (SIS) Model

The SIS model is a model used in epidemiology where population of N people is divided into two divisions: susceptible (S) and infected (I). Only when a susceptible person comes into contact with an infected person can the sickness be passed on and when this happens, Susceptible individuals (S) contract the infection and move into the infected class (I). After this, when an Infected individual recover swiftly then it will return to the susceptible class (S) [17].

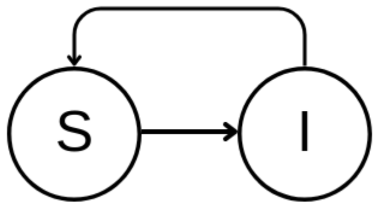

Figure 2.2: Flowchart for the Susceptible-Infected-Susceptible Model

Unlike the SI model, when a person gets infected, it could go back into being susceptible and become infected for the second time. There are various definitions of SIS models on networks that have been utilized in the literature of physics and mathematics [17].

2.2.3 Susceptible-Infected-Recovered (SIR) Model

One of the simplest compartmental models is the SIR model from which many other models are derived. The model has three compartments: S(t), which represents the number of susceptible people at time t, I(t), which represents the number of infectious people at time t, and R(t), which represents the number of removed (and immune) people at time t. For infectious diseases like measles, mumps, and rubella that are spread from person to person and where recovery gives long-lasting resistance, this model is reasonably predictive [27].

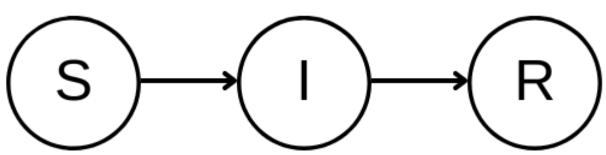

Figure 2.3: Flowchart for the Susceptible-Infected-Recovered Model

The model is dynamic in that the numbers in each compartment may change over time, as suggested by the variable function of t. When a disease is endemic and has a brief window of infectiousness, the significance of this dynamic aspect becomes more clear. Due to the fluctuation in the number of susceptibles (S(t)) over time, such diseases frequently go through cycles of outbreaks. When there is an epidemic, the susceptible population rapidly decreases as more people become infected and enter the removed and infectious compartments [27].

2.2.4 Susceptible-Infected-Recovered-Dead (SIRD) Model

The Susceptible-Infectious-Recovered-Deceased paradigm makes a distinction between Recovered and Deceased (i.e., people who have survived the infection and are now immune) [3].

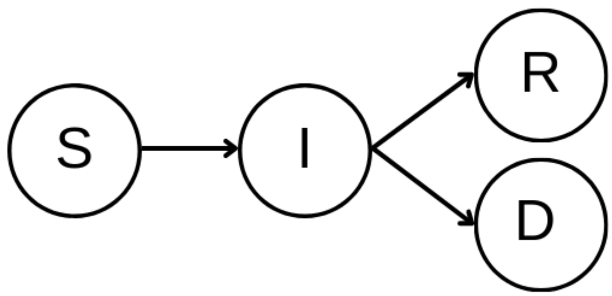

Figure 2.4: Flowchart for the Susceptible-Infected-Recovered-Dead Model

The recovery with immunity and death assumptions are two new ones added to the SIR model to create the SIRD model. This concept states that a susceptible person who comes in contact with an infected person is susceptible to contracting the disease. A person who is sick either survives the disease or dies from the virus. This model therefore assumes that the sum of S(t), I(t), R(t), and D(t) remain constant [21].

2.2.5 Susceptible-Exposed-Infected-Recovered-Dead (SEIRD) Model

Mathematical simulations of the transmission of infectious diseases are known as SEIRD models. A population's members can be classified into one of five states: either they are susceptible (S) to the disease, exposed (E) to the disease, infected (I) by the disease, or have either recovered (R) or died (D) from the disease. In this situation, we suppose that an exposed person is "pre-symptomatic," meaning that they have the potential to become sick or revert to being susceptible after the incubation period, whereas an infected person has symptoms and has tested positive for the disease [16].

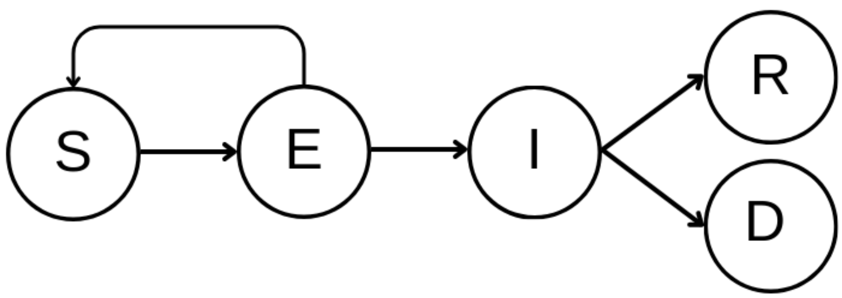

Figure 2.5: Flowchart for the Susceptible-Exposed-Infected-Recovered-Dead Model

By assuming that a population is evenly mixed, a compartmental SEIRD model ignores the population's network structure. In other words, we assume that on every given day, every member of the population has an equal likelihood of interacting with every member of the population. This presumption allows us to greatly simplify the system's current condition. We just need to keep track of the compartmental populations—the total number of people with each disease state—instead of specific people [16].

Chapter 3

Methodology

This section describes data sources used in this work, the proposed SEIRD model, and the formulation of the experiment to analyze the COVID 19 epidemic infection risks in National Center for Mental Health (NCMH).

3.1 COVID 19 Disease Model execution in NCMH

In this research, we simulated a closed society living on a shared finite environment, made up of humans that interact with one another. This classification will encompass the most important aspects of civilization and interaction inside the facility. The model will use five different types of agents, A, B, C, D, and E. **A** represents the susceptible agents, **B** are the exposed agents, **C** are the infected agents, **D** are the agents who were once infected but already recovered/immune to the virus, and **E** are the agents declared as dead due to the virus.

3.1.1 SEIRD Model

The following are the different types of agents considered in the experiment:

- Susceptible agents - Agents that are not immune and not infected, these are the agents that are at risk of being affected by the COVID 19 virus.
- Exposed agents - Exposed to the virus but are not infected, these are the agents that would likely incure the virus after its incubation period.
- Infected agents - Agents that has the virus and are capable to transmitting the virus to other agents.
- Recovered agents - Infected Agents that has recovered from the virus. They are also considered immune already and cannot incure the virus for the second time.

- Dead agents - Infected agents that has died due to the virus.

3.1.2 Parameters

In this study, the researcher considered the following parameters:

$S(t)$ to be the number of susceptible agents at time t. Initially set to 3995 agents.

$E(t)$ ot be the number of exposed agents at time t. Initially set to 0 agents.

$I(t)$ to be the number of infected agents at time t. Initially set to 5 agents.

$R(t)$ to be the number of recovered agents at time t. Initially set to 0 agents.

$D(t)$ to be the number of dead agents at time t. Initially set to 0 agents.

$N(t)$ to be the number of agent population inside the facility at time t. Initially set to 4000 agents.

ASpeed to be the movement speed of every agent inside the facility. The value of this is set to $5km/hr$.

Step to be the number of minutes per iteration. The value of this is set to 5 minutes.

EDistance to be the exposure distance where if an agent comes close to an infected agent for 15 minutes within a day, that agent will become exposed to the virus. The value of this is set to 2 meters.

$PInfection$ to be the probability of Infection for each agent. The value of this is randomized from $30\% - 80\%$ per agent.

PRecovery to be the probability of Recovery for each agent. The value of this is set to 80%.

PDeath to be the probability of Death for each agent. The value of this is set to 20%.

CDay to be the current day in the execution. Initially set to 1.

$SusToExp$ to be the time when susceptible agents would be considered exposed when that agent is less than or equal to the *EDistance* close to an infected agent. The value of this is set to 15 minutes for all agents.

$ExpToInf$ to be the number of days when exposed agents would be considered infected if it falls under the $PInfection$. The value of this is randomly set to $5-10$ days for each agent from the day the agent was considered exposed.

$InfToRec$ to be the number of days when infected agents would be considered recovered if it falls under the $PRecover$. The value of this is randomly set to $7-10$ days for each agent from the day the agent was considered infected.

$InfToDie$ to be the number of days when infected agents would be considered dead if it falls under the $PDeath$. The value of this is randomly set to $7-10$ days for each agent from the day the agent was considered infected.

$IRate$ to be the infection rate of the virus inside the facility. The formula that is used compute for the Infection rate is $\frac{I(t)}{N(t)}$.

3.2 Agent-Based Model Execution

In this section, we now solve the COVID 19 Disease Transmission inside the National Center for Mental Health facility by following the steps from section 3.2.1 to section 3.2.7 using the parameters indicated at section 3.1.2.

3.2.1 Setting up the Virtual Environment

The first step to execute the experiment was to set up the virtual environment where the experiment will take place. This virtual environment represents the National Center for Mental Health (NCMH) facility where there is a high probability of infection and interaction. For this model, a shape file for both buildings and roads generated from the Quantum Geographic Information System (QGIS) of the facility was used which was a 3-dimensional coordinate plane formed by the intersection of the x-axis, y-axis, and z-axis. The bounds for our experiment are denoted by the size of the facility.

Figure 3.1: Virtual Representation of the National Center for Mental Health where the experiment took place.

The agents will freely move and interact in this virtual environment as seen in figure 3.1. After setting up the virtual environment, the next step done was to position all our agents in the map.

3.2.2 Initial positioning of all the Agents inside the virtual environment

Our model considered five types of agents, the susceptible agents, the exposed agents, the infected agents, the recovered agents, and the dead agents. The susceptible agents represented individuals who were likely to be infected with COVID-19. The exposed agents represented the individuals who have been exposed to the virus for 15 minutes within a day. The infected agents represented the individuals who were already infected with COVID-19. Recovered agents were the people who got infected but recovered after a specified day, they were also considered immune to the virus. And lastly, dead agents represented agents who died due to the virus and not by any other means. The set **A** represented the set of susceptible agents, set **B** represented the exposed agents, set **C** represented the infected agents, set **D** represented the set of recovered agents, and set **E** represented the set of dead agents. For the next step which is initialization, all agents will be positioned randomly within the virtual map as can be seen in figure 3.1 specifically in one of the buildings in the facility.

This positioning of all agents was executed until all the agents that will take part in the experiment was placed inside the virtual environment. When all the agents was positioned, the next step was to assign a Probability of Infection to all susceptible agents inside the facility.

3.2.3 Assigning Probability of Infection *(PRI)* to all susceptible agents in the facility

An individual's probability of being infected depends on various factors, from health conditions to discipline in following the prevention measurements. Like the fire spreading model, where multiple factors affect fire spread from one tree to another, agent-based modeling allows simplifying factors affecting a process like the fire spreading and transmission of diseases using random numbers [26].

For the description, to each agent from **A**, a Probability of Infection was assigned. For this experiment, to be able to visualize the behavior of the transmission of the virus, the researcher used a 30%-80% as the Probability of Infection given that most agents in the facility was mentally unstable agents thus, could not properly follow preventive measurements. The reason why PRI was random on each susceptible agent was to provide a more realistic result. Since, in reality, each person has various levels of immunity. Thus, it is important for susceptible students to have diverse characteristics. After we assigned a PRI to each agents from **A**, the next step done was to assign a movement to each agents in sets **A**, **B**, **C**, **D**, and **E**.

3.2.4 Assigning the movement of each agents inside the facility

In this step, for each agent, a target location for the next iteration was implemented. During the experiment, the movement of the agents varied depending on the current day and time as well as the moderation being set for each situation. All agents had a constant speed of $5km/hr$ and had a higher chance of mobility at hours 9-11am and 3-6pm since these are the times the patients were most active (doing their exercises, activities, etc.), from 7pm-6am, mobility of each agents was slowed down since the researcher considered the nap time of each agents in the facility.

On cases where implementation of lockdown was currently effective

During an implementation of a lockdown, agents could only move on their specified building for 14 days and their target location would only be on the same building where they currently are.

On cases where the implementation of quarantine for infected agents was currently effective

During an implementation of quarantine for Infected Agents, these agents could only move on where their assigned quarantine area was until they have recovered from the virus depending on each agent's generated $InfToRec$ value. They were restricted from moving to other places to avoid them in exposing other agents from the virus.

Now that the movement of each agent inside the facility was already determined, next step was to figure out whether the infected agents exposes the susceptible agents in facility. This was where the characteristics of each agent would come in. So, given the positions of all the agents in our virtual environment, it will be now be checked if the susceptible agents would be exposed from the virus.

3.2.5 Identifying if a susceptible agent will get exposed or not

In this step, to identify if an agent a from $\mathbf{A}$ will get exposed or not. For each agent a from $\mathbf{A}$, the existence of an infected agent c from $\mathbf{C}$ inside a neighborhood $EDistance$ (which is a specific distance) was analyzed. For this study, it used $EDistance = 2$ meters. If an infected agent was found within a neighborhood of a susceptible agent for $SusToExp$ which was 15 minutes within the day, then that agent will be considered exposed and be added on the number of exposed agents at time t, $E(t) = E(t) + 1$ and will be labeled as color yellow as could be seen in figure 3.2. The agent that has been exposed will be subtracted from the number of susceptible agents at time t thus, $S(t) = S(t) - 1$.

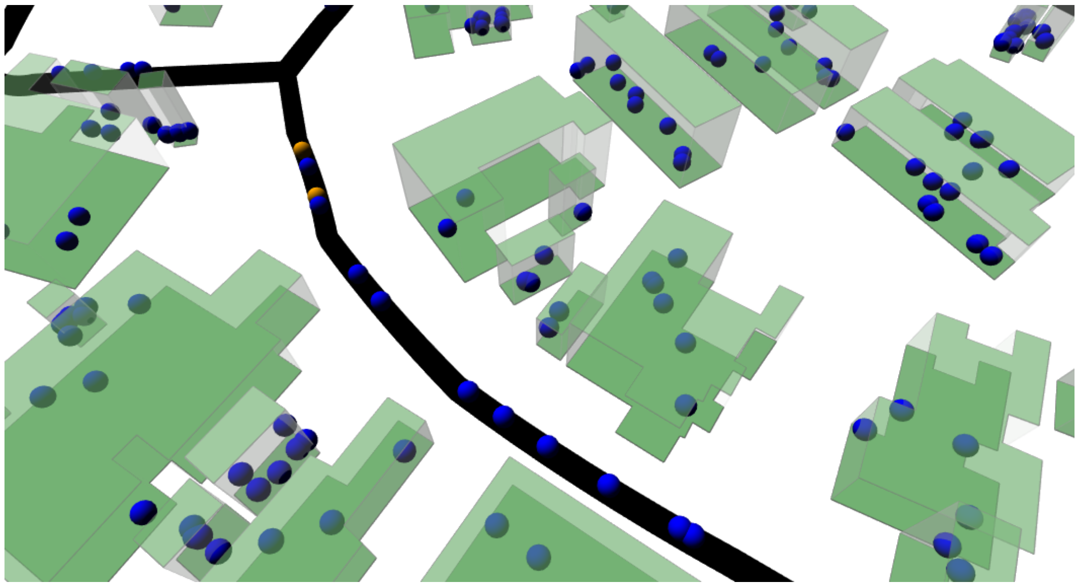

Figure 3.2: Detecting exposed agents in simulations, yellow agents were COVID19-exposed.

To compute for the 2 meter range of each susceptible student, the researcher used the standard equation of the circle, which is $(x-h)^2 + (y-k)^2 = r^2$, where (h,k) is the coordinates of the center of the circle, and r is the radius. After the generated $ExpToInf$ days of being exposed for the agent, a probabilistic test which was the $PInfection$ was done to evaluate if the exposed agent will be infected or not.

3.2.6 Identifying if an exposed agent will get infected or not

A random probability of infection ($PInfection$) was generated within a uniform distribution from 0.3 to 0.8 after the generated $ExpToInf$ day for each exposed agents. If the value generated was close to 0.3, it means that the exposed agent has 30% chance of being infected. Otherwise, if 0.8 it means that the exposed agent has 80% probability of being infected. If an exposed agent became infected then that agent will be added on the number of infected agents at time t, $I(t) = I(t) + 1$ and will be subtracted from the number of exposed agents at time t, $E(t) = E(t) - 1$. Infected agents was labeled as color red as could be observed in figure 3.3

Figure 3.3: Detecting infected agents in simulations, red agents were COVID19-infected.

After this step, the researcher now saw how each exposed agent become infected. The next step was to determine whether an infected agent will recover or die.

3.2.7 Identifying if an infected agent will recover or die from the virus

In this step, after the generated $InfToRec$ days of being infected of an agent c in set C. There was 80% chance of recovering for the agent which we will label as agent d from set D. If the agent doesn't recover, it means it died from the virus and will be categorized as an agent e from set E. For this experiment, agents who recovered from the virus was considered as immune and cant be infected anymore otherwise, that agent was considered dead. Agent who recovered will be added on the number of recovered agents at time t, $R(t) = R(t) + 1$ and be subtracted from the number of infected agents at time t, $I(t) = I(t) - 1$ while agents who died will be added on the number of dead agents at time t, $D(t) = D(t) + 1$ and be subtracted from the number of infected agents at time t,

$I(t) = I(t) - 1$. Recovered agents was labeled as color pink while agents who died was labeled as color black as could be seen in figures 3.4 and 3.5.

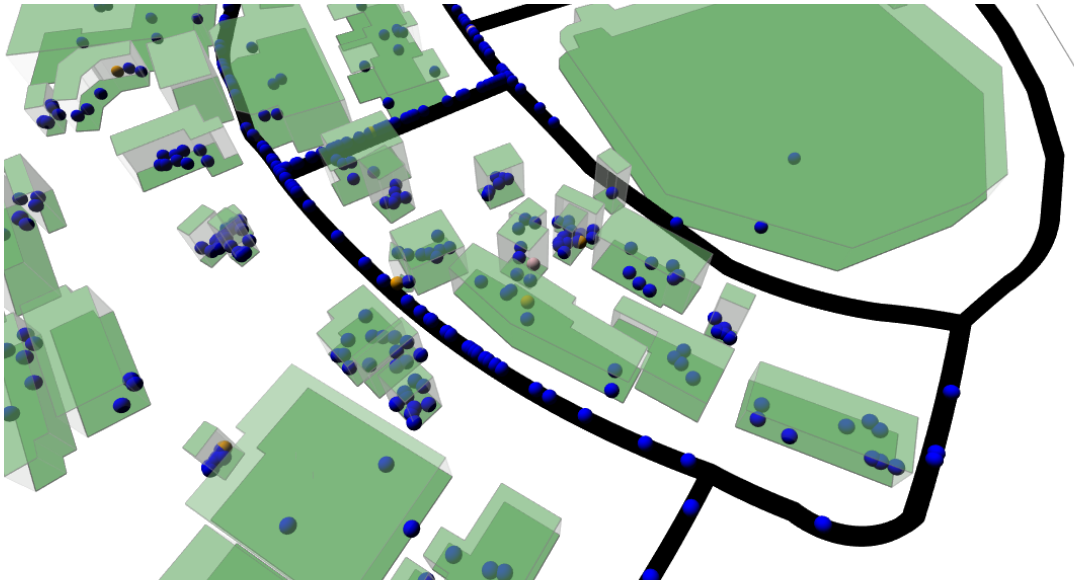

Figure 3.4: Detecting recovered agents in simulations, pink agents were COVID19-recovered.

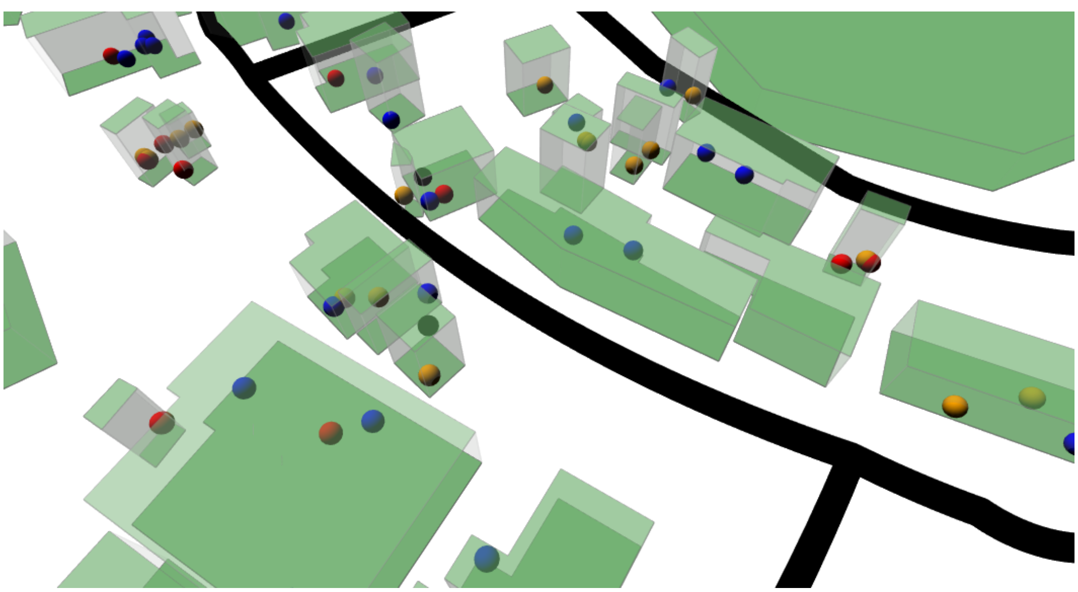

Figure 3.5: Detecting dead agents in simulations, black agents were dead agents due to the virus.

This process was conducted until there were no more exposed and infected agents left, meaning that the virus transmission has come to an end or the infection rate, $IRate$, has reached 1 meaning all remaining agents were currently infected. The model for assessing COVID-19 transmission risks was built as an iterative method that took into account some processes during operation.

The researcher recorded and observed how long, based on the number of days, it took for the overall number of exposed and infected agents to increase based on different moderation applied. Also, this study aimed to help authorities make an informed decision to lessen the risks of transmitting the virus in the NCMH facility. Thus, this experiment explored the effects of having different moderation in the facility and compared the results of each simulation to know which configuration and scenario would result in a low transmission rate. Basically, the researcher compared each scenario and observed how the condition of the facility affected the overall result and how fast the infection rate was, based on the result of the experiment.

The model code in the GAMA Platform was simple and can be coded in a matter of lines. The outcome of each experiment which was the number of the infected, recovered, and dead agents was considered as the predicted numbers inside the facility for a specified days or months. [25]

3.3 Gathering of Data

Real population data were collected from the National Center for Mental Health as they stated that they currently has 451 nurses handling an average daily number of 3,500 in-patients in 2020, which was a total of 3951 people [7]. Therefore in this experiment, the researcher rounded up the data and used a population of 4000 agents where 5 of them was initially considered infected. Since most agents were mentally unstable which resulted into them not being able to properly follow preventive protocols, $PInfection$ was exaggerated to study the behavior of the virus transmission. A statistical model indicated that the mean incubation period of COVID 19 is 5.6 to 6.7 days but when the average patient age was 60 years old, the 95th percentile would become 12.5 days, rising 1 day every 10 years [19]. For this study, the researcher has set the $ExpToInf$

into 5-10 days before an exposed agent becomes infected. On average, about 98.2% of known COVID-19 patients in the U.S. survive [4] therefore the $PRecovery$ used for every infected agents in this research was 80%. The average recovery time for those who have mild or normal cases of COVID-19 or flu was up to 14 days [5] so the $InfToRec$ day the researcher used was randomized from 7-10 days before an infected agent recovers or dies.

Chapter 4

Results and Discussion

Multiple runs were done to attain results for this parameter identification problem. The moderation that was executed varied where the researcher considered implementing a 14-day lockdown both on 2nd to 3rd weeks of each month and 3rd to 4th weeks of each month. Executing a quarantine area for infected agents was also considered in this experiment and the combination of the implementation of lockdown for all agents and quarantine are for all infected agents to see what moderation was best suited to minimize the COVID transmission risk inside the NCMH facility.

5 different runs were done for each scenarios and the average number of susceptible, exposed, infected, recovered, and dead agents per day was examined and the results attained from each scenario was compared to the results of the other scenarios with moderation in order the identify the behavior of each agents based on what moderation was being implemented. The following was the findings and analysis on the behavior of agents based on different scenarios being implemented.

4.1 Scenario 01: Basic Experiment

In this section, the experiment was ran without moderation even if the infected number or agents blow up for days, weeks, or months. This helped the researcher to observe the virus transmission and behavior of each agents when no moderation was applied.

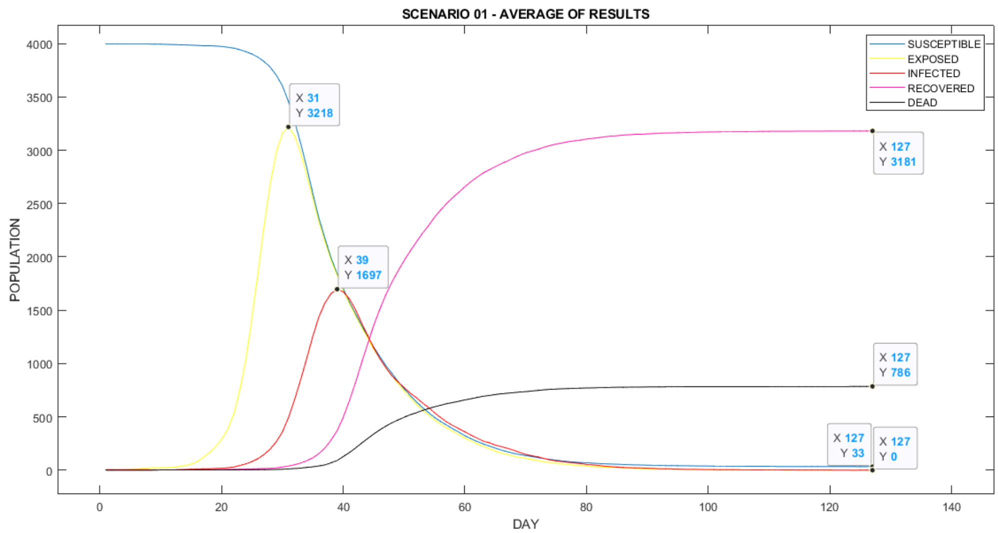

Figure 4.1: The average time series daily chart of scenario 01 when 5 runs was executed.

From 4.1, at day 0, there were a total of 4000 population with 5 being infected. On day 31, the peak of number of exposed agents was reached where 3218 agents were currently exposed while at day 39, the peak of number of infected agents was reached where 1697 agents were currently infected. Given that 1697 agents were currently infected at day 39 and 3218 agents were currently exposed at day 31, approximately 52.7346% of the exposed agents on day 31 have been infected on day 39 which was computed using the formula:

$$(\frac{1697}{3218}) * 100 = 52.7346\%$$

At day 127, there were no more remaining exposed and infected agents in the experiment which means that this was the time where the transmission of COVID-19 disease stopped. Out of all the 4,000 agents, 3181 have recovered which was 80.19% of the overall infected population and 786 died which was 19.81% of the overall infected population which summed that the overall affected agents in this scenario were 3967 which was 99.1750% of the population. The following data was computed using the following formulas:

$$Affected = (\frac{3967}{4000}) * 100 = 99.1750\%$$

$$Recovered = (\frac{3181}{3967}) * 100 = 80.19\%$$

$$Dead = (\frac{786}{3967}) * 100 = 19.81\%$$

4.2 Scenario 02.1: Implementation of a scheduled lockdown on 2nd and 3rd weeks of each month

For this scenario, the experiment was ran with the execution of a scheduled lockdown to observe how this moderation affected the behavior of agents and if the virus transmission risk inside the facility was minimized. Once the experiment reached day 07, there was a 14-day long lockdown that was implemented. These lockdown was implemented every 2nd and 3rd weeks of the month. During the lockdown, no one was allowed to move from one building to another and would just stay on the same building for the entire lockdown period whether each agent was categorized as a susceptible, exposed, infected, or recovered agent. Implementing this helped the researcher observe the possible number of infected cases when this moderation was applied as compared to the scenario 01 when no restriction was applied.

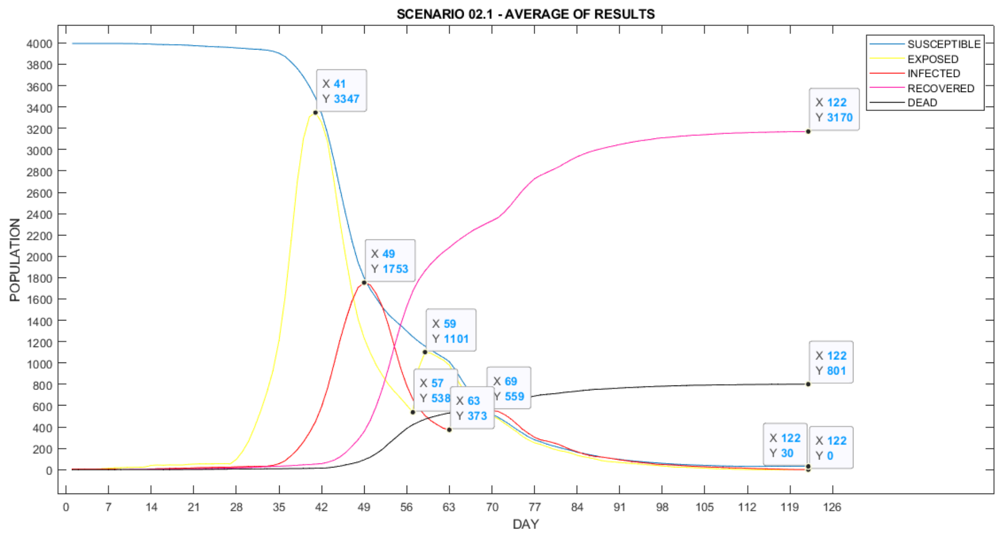

Figure 4.2: The average time series daily chart of scenario 02.1 when 5 runs was executed.

From 4.2, on day 0, there were a total of 4000 population with 5 being infected. On day 36, the peak of number of exposed agents was reached where 3060 agents were currently exposed while on day 44, the peak of number of infected agents was reached where 1551 agents were currently infected. On day 52, wave 2 was evident since another peak in number of exposed agents has reached and 1534 agents were currently exposed. On day 61, wave 2 was also evident since another peak in number of infected agents has reach and 797 agents were currently infected. On day 141, there were no remaining exposed and infected agents in the experiment which meant that this was the time where the transmission of COVID stopped.

It was observed that the peak number of exposed agents was reached at day 36 and dropped until day 50. The researcher took a closer look on this as visualized in 4.3

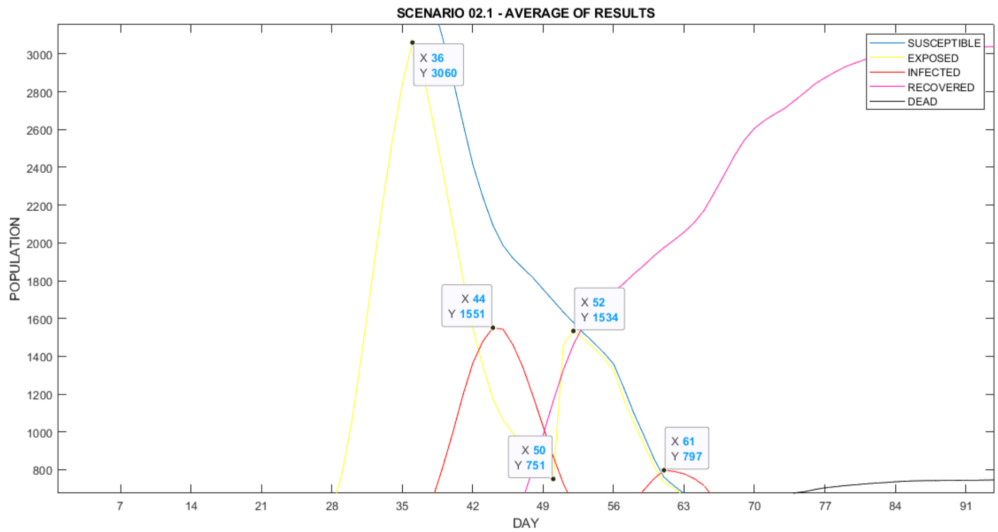

Figure 4.3: The average time series daily chart of scenario 02.1 on days 36-50 when 5 runs was executed.

On days 7-20, the first lockdown was implemented and the second lockdown happened on days 37-50. Figure 4.4 was the GAMA representation of how the lockdown was implemented on days 37-50 during this scenario's first run. Figure 4.5 was a closer look where it was evident that during the scheduled lockdown, the road was closed and no agents were allowed to roam around. As observed on figure 4.3, the lockdown gave an affirmative effect on reducing the number of exposed agents by 2309 agents, approximately 75.46% of the peak in 14 days which was computed using the formula:

$$(1 - (\frac{751}{3060})) * 100 = 75.4575\%$$

Figure 4.4: Scenario 02.1's initial run on the 37th day of lockdown until the 50th. No agents moved between buildings.

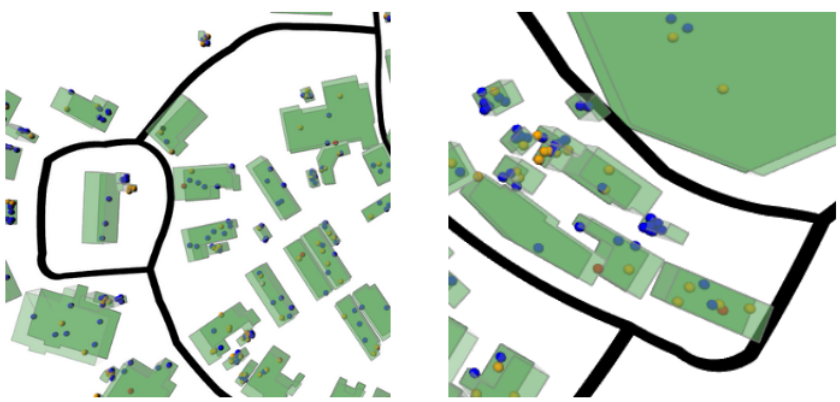

Figure 4.5: Closer look on 4.4. The lockdown prevented all types of agents from moving between buildings.

The most number of infected agents during the execution was observed in this range wherein at day 44, which was 8 days after the start of lockdown, the number of infected agents reached 1551. The increase in number of infected agents during lockdown happened because most of the exposed agents at day 36, which was the day before lockdown, likely already incurred the virus at day 44, which was 8 days after the agent's exposure, on the same day range that we were trying to minimize the number of newly exposed agents by imposing a lockdown.

Based on 4.3, the number of exposed agents once again increased from day 50 to day 52 then decreased continuously. Also, the number of infected agents decreased from day 44 to 55, increased again at day 61, then decreased continuously after. The researcher took a closer look on why this happened, 4.6 was a representation of how the number of exposed agents behaved in this scenario.

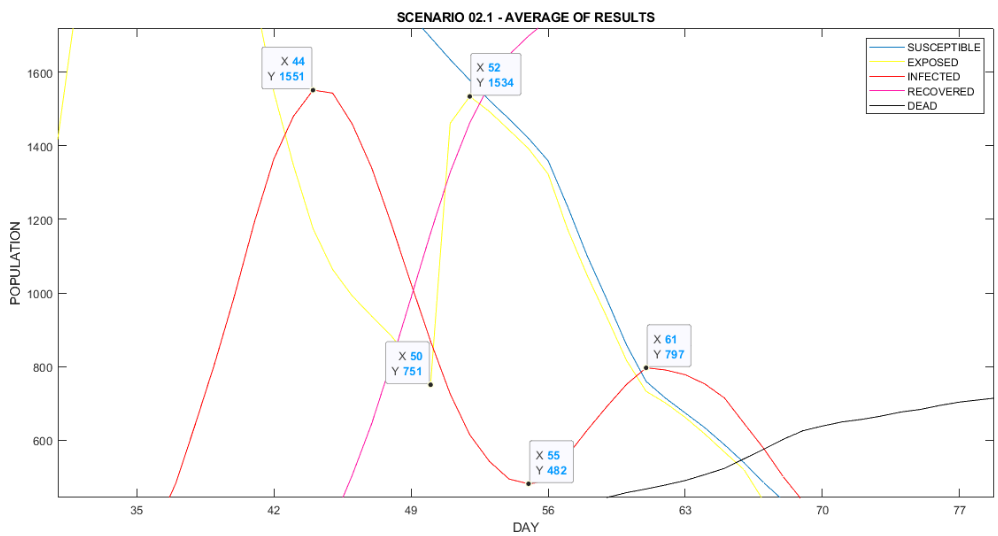

Figure 4.6: The average time series daily chart of scenario 02.1 from days 44-61 when 5 runs was executed.

The second lockdown has ended on day 50 which made all the agents free again to roam around the facility after as visualized in figure 4.7 which was the same for all runs in this scenario. Because of this, it was evident from figure 4.6 that the number of exposed agents increased from 751 to 1534, approximately 204 % in a span of 2 days which was risky because after the lockdown, the agents suddenly started to socialize again making them prone into getting exposed and infected once again.

$$(\frac{1534}{751}) * 100 = 204\%$$

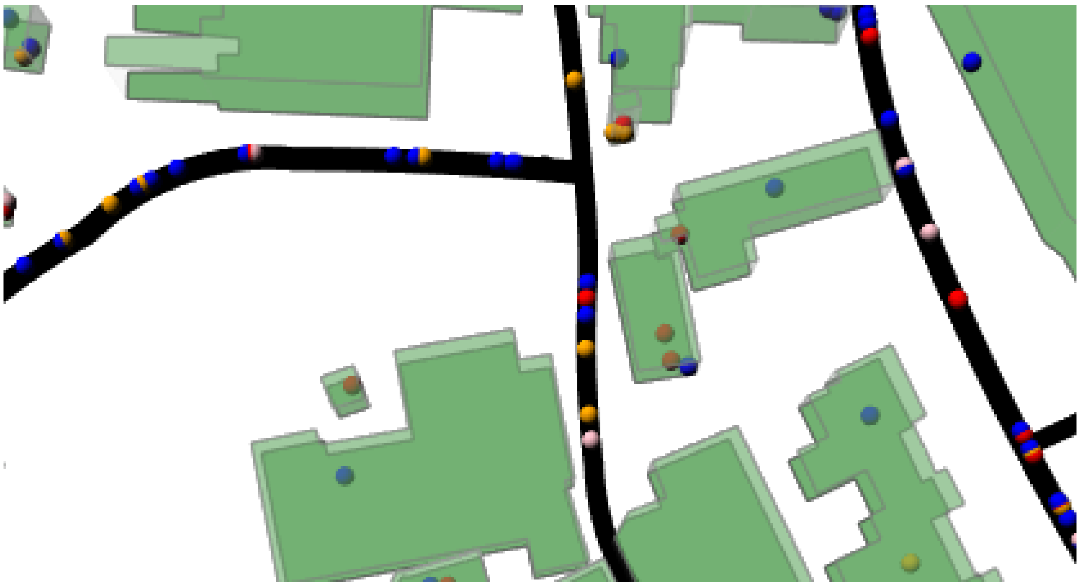

Figure 4.7: A perspective view for scenario 02.1 on day 51 when lockdown was already lifted. Roads were once again passable.

The number of infected agents once again increased from 482 on day 55 to 797 on day 61. Because of this, the researcher have observed that even though the lockdown was effective in decreasing the number of infected agents, people in the facility still must do a restriction after to refrain the number of infected agents into rising up again.

Out of all the 4,000 agents, 3118 have recovered and 786 died which summed that the overall affected agents were 3888 which was 97.2% of the population. The following data was computed using the following formulas:

$$Affected = (\frac{3888}{4000}) * 100 = 97.2\%$$

$$Recovered = (\frac{3118}{3888}) * 100 = 80.1955\%$$

$$Dead = (\frac{786}{3888}) * 100 = 20.2160\%$$

4.3 Scenario 02.2: Implementation of a scheduled lockdown on 3rd and 4th weeks of each month

For this scenario, the experiment was ran with the execution of a scheduled lockdown to observe how this moderation affected the behavior of agents and if the virus transmission risk inside the facility was minimized. Once the experiment reached day 14, there was a 14-day long lockdown that was implemented. These lockdown was implemented every 3rd and 4th weeks of the month. During the lockdown, no one was allowed to move from one building to another for all types of agents. Implementing this helped the researcher observe the possible number of infected cases when this moderation was applied as compared to the scenario 01 when no restriction was applied and scenario 02.1 when the implementation of a scheduled lockdown on 2nd and 3rd weeks of each month was implemented.

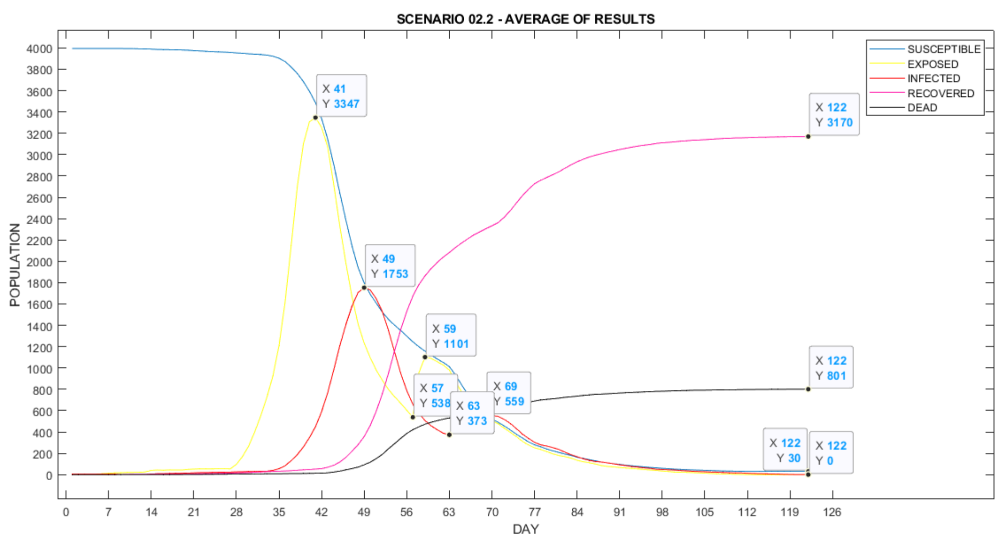

Figure 4.8: The average time series daily chart of scenario 02.2 when 5 runs was executed.

From 4.8, on day 0, there were a total of 4000 population with 5 being infected. On day 41, the peak of number of exposed agents was reached where 3347 agents was currently exposed while on day 49, the peak of number of infected agents was reached where 1753 agents were currently infected. On day 59, wave 2 was evident since another peak of number of exposed agents has been reached where 1101 agents were currently exposed. On day 69, wave 2 was also evident since another peak of number of infected agents has been reached where 559 agents were currently infected. On day 121, there were no remaining exposed and infected agents in the experiment which means that this was the time where the transmission of COVID inside the facility stopped.

The peak number of exposed agents was reached at day 41 and dropped until day 57. The researcher took a closer look on this as visualized in 4.9.

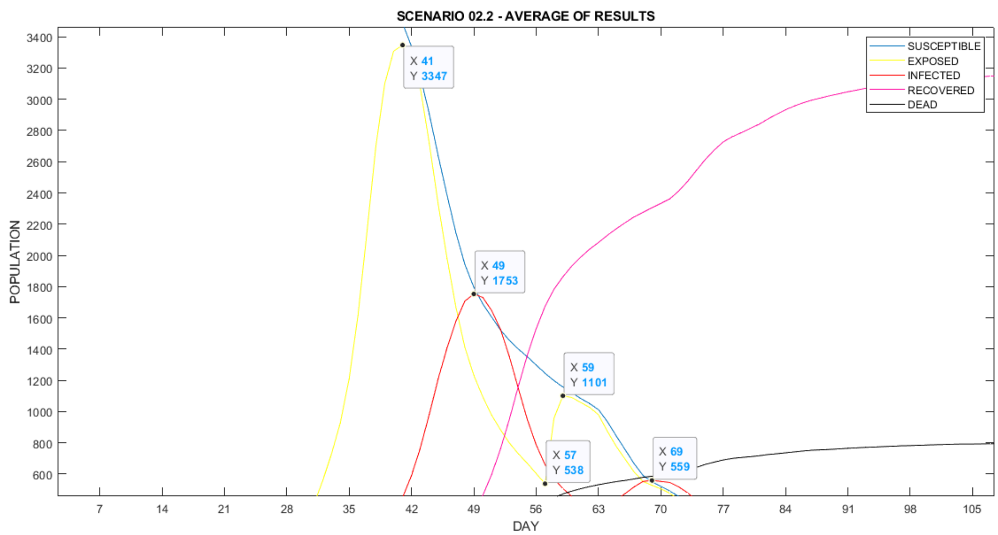

Figure 4.9: The average time series daily chart of scenario 02.2 from day 41-57 when 5 runs was executed.

On days 14-27, the first lockdown was implemented and the second lockdown happened on days 44-57. Based on figure 4.9, the lockdown gave an affirmative effect on reducing the number of exposed agents by 2809 agents, approximately 83.93% of the peak in 14 days which was computed using the formula:

$$(1 - (\frac{538}{3347})) * 100 = 83.9259\%$$

The most number of infected agents during the execution was also observed in this range wherein at day 49, which was 5 days after the start of lockdown, the number of infected agents reached 1753. The increase in number of infected agents during lockdown happened because most of the exposed agents at day 41, 3 days before lockdown most likely already incurred the virus at day 49, which was 8 days after the agent's exposure on the same day range that we try to minimize the number of newly exposed agents by imposing a lockdown.

Based on 4.8, the number of exposed agents once again increased from day 57 to day 59 then decreased continuously. Also, the number of infected agents decreased from day 49 to 63, increased again until day 69, then decreased continuously after. The researcher took a closer look on why this happened, 4.10 was a representation of how the number of exposed agents behaved in this scenario.

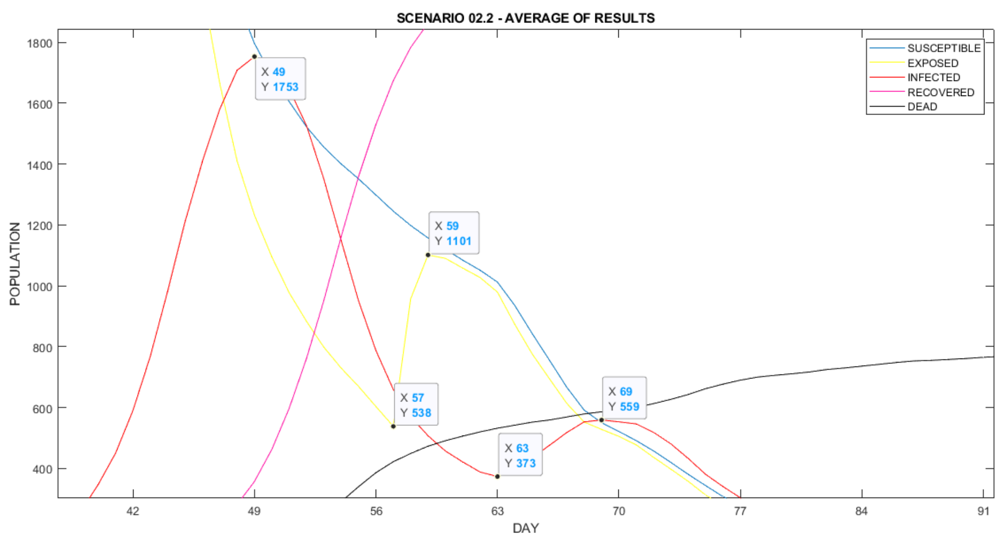

Figure 4.10: The average time series daily chart of scenario 02.2 from day 49-69 when 5 runs was executed.

The second lockdown has ended on day 57 which made all the agents free again to roam around the facility after. Because of this, it was observed from figure 4.10 that the number of exposed agents increased from 538 to 1101, approximately 204% in a span of 2 days which was risky because after the lockdown, the agents suddenly started to socialize again making them prone into getting exposed and infected once again.

$$(\frac{1101}{538}) * 100 = 204.6468\%$$

Infected agents once again rised up from 373 on day 63 to 559 on day 69. Even though the lockdown was effective in decreasing the number of infected agents, people inside the facility must do a restriction after to refrain the number of infected agents into rising up again.

Out of all the 4,000 agents, 3170 have recovered and 801 died which summed that the overall affected agents were 3971 which was 99.28% of the population. The following data was computed using the following formulas:

$$Affected = (\frac{3971}{4000}) * 100 = 99.275\%$$
$$Recovered = (\frac{3170}{3971}) * 100 = 79.8288\%$$
$$Dead = (\frac{801}{3971}) * 100 = 20.1712\%$$

4.4 Scenario 03: Providing quarantine areas for Infected agents

For this scenario, the experiment was ran with the execution of providing an isolation area for the infected agents and observed how this moderation affected the behavior of agents and if the virus transmission risk inside the facility was minimized. After 7 days in the facility, isolation areas was opened for all the infected agents where they had to stay there until they have recovered or die from the virus. Implementing this helped the researcher observe the possible number of infected cases when this moderation was applied as compared to the scenario 01 when no restriction was applied and scenarios 02.1 and 02.2 when scheduled lockdown was implemented.

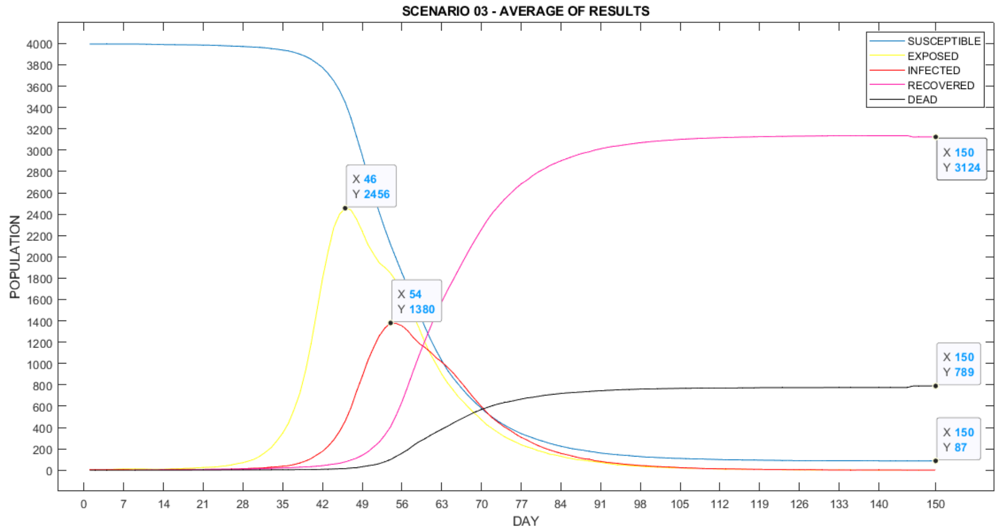

Figure 4.11: The average time series daily chart of scenario 03 when 5 runs was executed.

Figure 4.12: Scenario 03's first implementation in the experiment. Infected agents were isolated on some premises to avoid long-term interaction with other agents.

Figure 4.13: On category A, non-infected agents roamed around and transferred between buildings, but on category B, there was a limiting access since the quarantine area was near to the road.

Figure 4.12 was a visual representation of how the infected agents were being isolated to refrain them into exposing the other agents while figure 4.13 was a closer look on it and was showed that on category A, the non-infected agents were roaming around since their target buildings were the buildings that was not designed as an isolation area for infected agents while on category B, a lower number of agents were roaming on that side of the road since it was closer to the quarantine area and the possible agents that were only allowed to roam there are the agents that were infected and are on their way to the quarantine area or the agents from the quarantine area that has already recovered from the virus. From 4.11, on day 0, there were a total of 4000 population with 5 being infected. On day 46, the peak of number of exposed agents was reached where 2456 agents were currently exposed while on day 54, the peak of number of infected agents was reached where 1380 agents were currently infected. On day 150, there were no remaining exposed and infected agents in the experiment. This means that this was the time where the transmission of COVID stopped and out of all the 4,000 agents, a total of 3914, 97.85% were affected by the COVID 19 virus where 3124, 79.82% have recovered and 789, 20.16% died. The following data was computed using the following formulas:

$$Affected = (\frac{3914}{4000}) * 100 = 97.85\%$$
$$Recovered = (\frac{3124}{3914}) * 100 = 79.82\%$$
$$Dead = (\frac{789}{3914}) * 100 = 20.16\%$$

4.5 Scenario 04: Implementation of a scheduled lockdown for all agents and providing quarantine areas for all Infected agents

For this scenario, the experiment was ran with the execution of implementing scenario 02.1 and scenario 03 together and observed how by combining these two moderation affected the behavior of agents and if the virus transmission risk inside the facility was minimized. After 7 days, isolation areas was opened for the infected agents where they had to stay there for 14 days or until they have recovered or died from the virus at the same time, lockdown of all building was also implemented during 2nd and 3rd weeks of the month. Implementing this helped the researcher observe the possible number of infected cases when this moderation was applied as compared to the scenario 01 when no restriction was applied, scenarios 02.1 and 02.2 when a scheduled lockdown was implemented, and scenario 03 when quarantine areas for infected agents were provided.

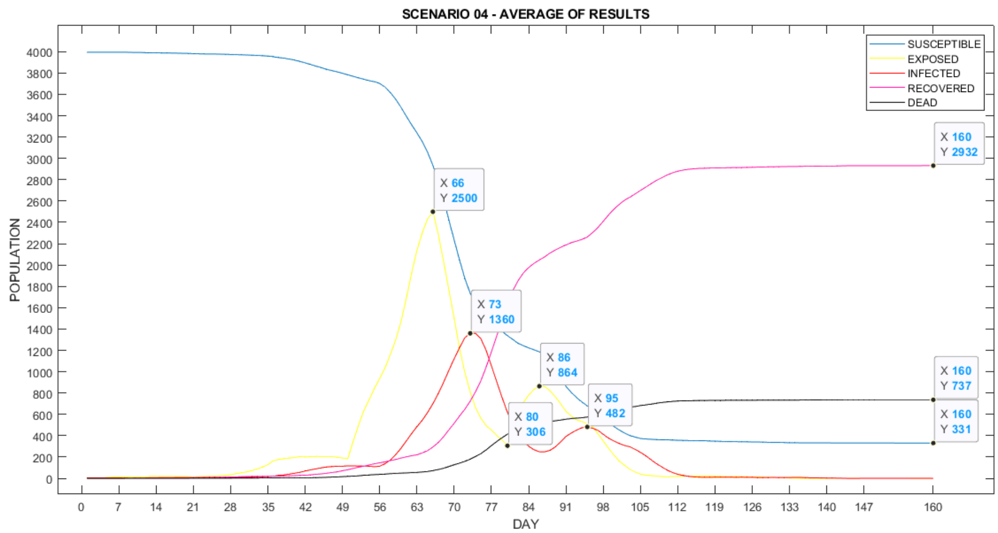

Figure 4.14: The average time series daily chart of scenario 04 when 5 runs was executed.

From 4.14, on day 0, there were a total of 4000 population with 5 being infected. On day 66, the peak of number of exposed agents was reached where 2500 agents were currently exposed while on day 73, the peak of number of infected agents was reached where 1360 agents were currently infected. On day 86, wave 2 was evident since another peak of number of exposed agents has been reached where 864 agents were currently exposed. On day 95, wave 2 was evident since another peak of number of infected agents has been reached where 482 agents were currently infected, and on day 160, there were no remaining exposed and infected agents in the experiment which means that this was the time where the transmission of COVID stopped.

The peak number of exposed agents was reached at day 66 and dropped until day 80. This has happened because on days 67-80, a 14-day lockdown was implemented as could be visualized in figure 4.26 at the same time infected agents were being isolated. As observed on figure 4.14, the lockdown gave an affirmative effect on reducing the number of exposed agents by 2194 agents, approximately 87.76% of the peak in 14 days which was computed using the formula:

$$(1 - (\frac{306}{2500})) * 100 = 87.76\%$$

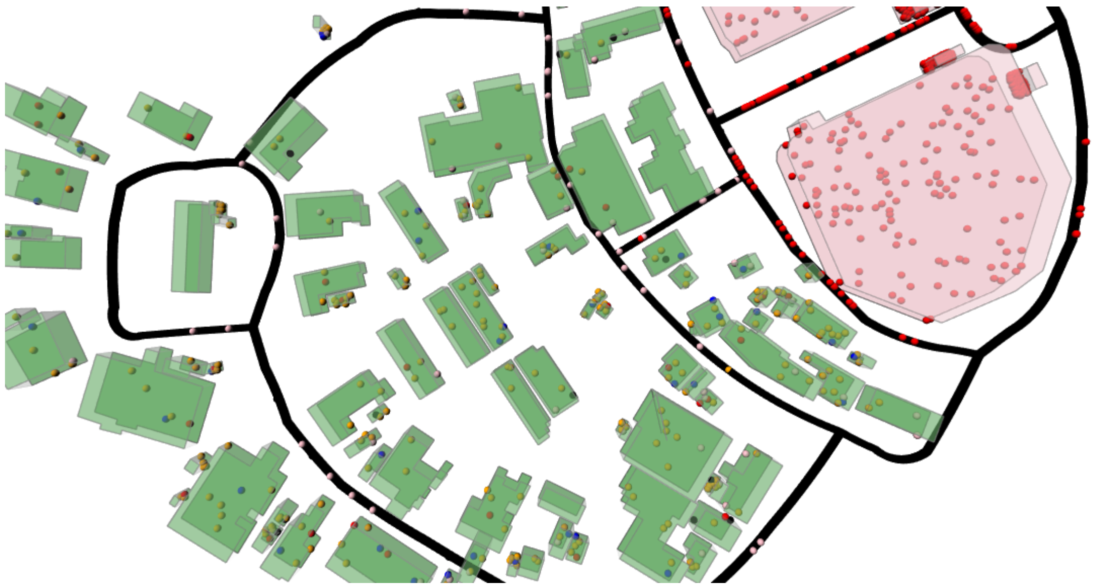

Figure 4.15: First run of scenario 04. Despite the lockdown, infected agents were kept separated in quarantine buildings. Infected and Recovered Agents on the road were either headed to the isolation area or returning to their buildings.

The most number of infected agents during the execution was also observed in this range wherein at day 73, which was 7 days after the start of lockdown, the number of infected agents reached 1360. The increase in number of infected agents during lockdown happened because most of the exposed agents at day 66, 1 day before lockdown most likely already incurred the virus at day 73, 7 days after the agent's exposure on the same day range that the we tried to minimize the number of newly exposed agents by imposing a lockdown.

The number of exposed agents once again increased from day 80 to day 86 then decreased continuously. Also, the number of infected agents decreased from day 73 to 86, increased again until day 95, then decreased continuously after.

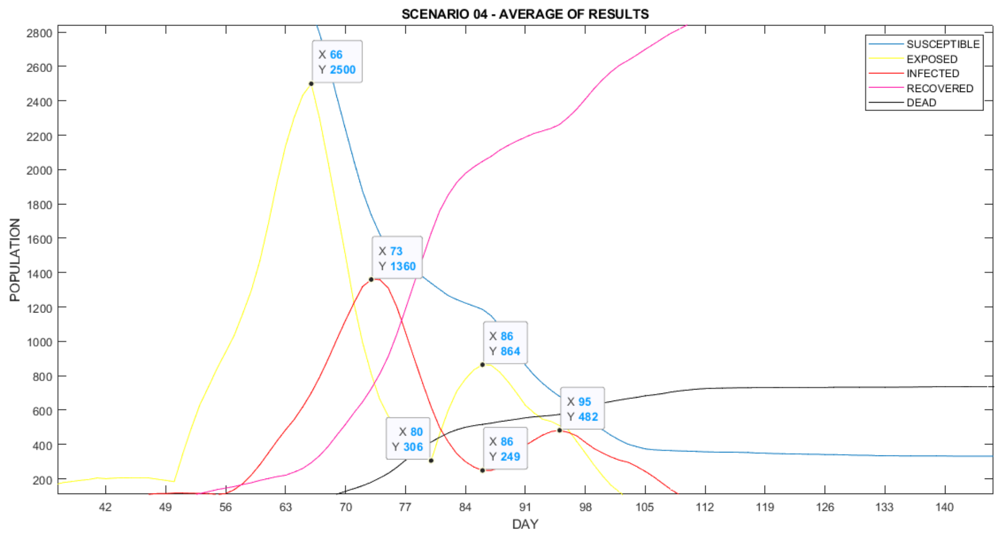

Figure 4.16: The average time series daily chart of scenario 04 from days 66-95 when 5 runs was executed.

The second lockdown has ended on day 80 which made all the agents free again to roam around the facility after. Because of this, from figure 4.16, the number of exposed agents increased from 306 to 864, approximately 282% in a span of 6 days which was risky because after the lockdown, the agents suddenly started to socialize again making them prone into getting exposed and infected once again even if the infected agents were quarantined.

$$(\frac{864}{282}) * 100 = 282.3529\%$$

The number of infected agents once again increased from 249 on day 86 to 482 on day 95. Even though the lockdown was effective in decreasing the number of infected agents, people in the facility still must do a restriction after to refrain the number of infected agents into rising up again. The behavior of implementing scenario 04 was the same with the behavior when implementing scenario 02.1 but the numbers became smaller which showed that the additional implementation of isolation areas for infected agents gave a significant impact in minimizing the number of infected agents when combined with the implementation of lockdown.

Out of all the 4,000 agents, a total of 3669, 91.73% were affected by the COVID 19 virus where 2932, 79.91% have recovered and 737, 20.09% died. The following data was computed using the following formulas:

$$Affected = (\frac{3669}{4000}) * 100 = 91.73\%$$
$$Recovered = (\frac{2932}{3669}) * 100 = 79.91\%$$
$$Dead = (\frac{737}{3669}) * 100 = 20.09\%$$

4.6 Comparing the behavior of the number of Exposed agents of all scenarios

In this section, the researcher observed the highest number of current exposed agents, which was the peak per scenario and compared the numbers to the other scenarios to observe why and how it happened. Figure 4.17 showed the number of exposed agents in the facility from day 01, the first day with 0 number of exposed agents to day 155, the last day when it went back into 0 number of exposed agents.

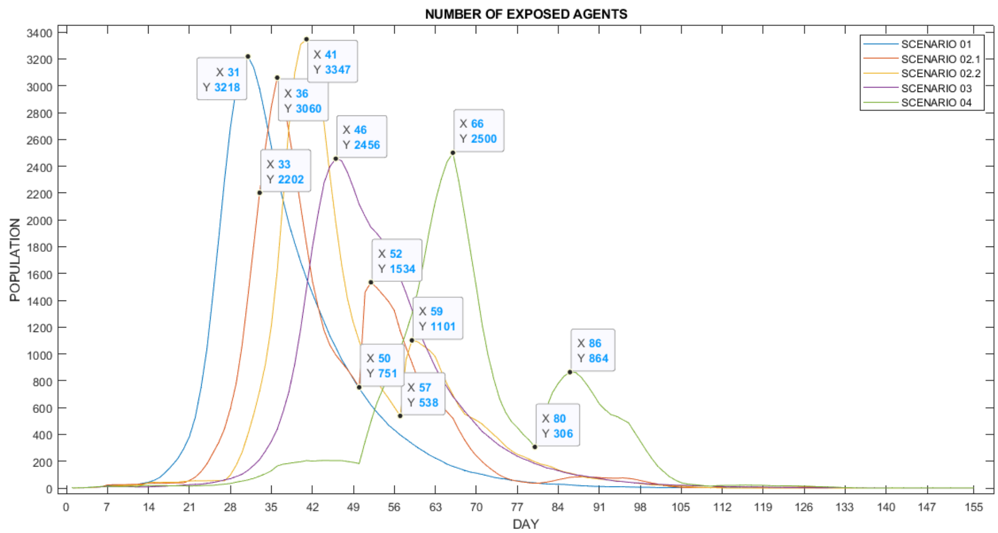

Figure 4.17: The average time series daily chart of the number of Exposed agents in all scenarios when 5 runs was executed.

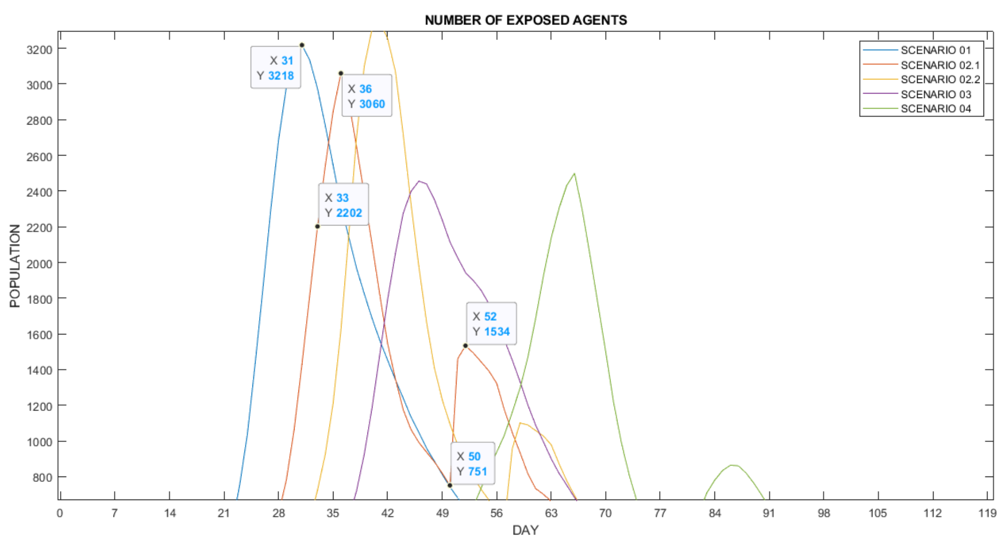

Figure 4.18: The average time series daily chart of the number of Exposed agents in scenario 01 and 02.1 when 5 runs was executed.

Starting from scenario 01, the most number of exposed agents was reached at day 31 with 3218 agents exposed. In scenario 02.1, the most number of exposed agents was reached at day 36 with 3060 agents exposed. As showed in 4.18, the only difference between scenarios 1 and 02.1 on days 1-36 was the implementation of 14-day scheduled lockdown of scenario 02.1 on days 7-20 which resulted on the delay in reaching the maximum number of exposed agents by 7 days and lowering this number by 158 agents. The decrease in the number of exposed agents on days 37-50 was a result of the 2nd lockdown being implemented in scenario 02.1 which proved that the implementation of lockdown gave a favorable result in minimizing the potential number of infected agents during the execution but unfortunately, after day 50 which was the end of the lockdown, the number of exposed agents once again increased mainly because the agents have once again became free of roaming around the facility without limits on what they can do or where they could go. 4.19 was a screenshot of the scenario 02.1 execution at day 51.

Figure 4.19: Scenario 02.1's first run on day 51. After the lockdown was lifted, the agents began socializing.

As a result, another wave became evident increasing the number of newly exposed agents on these days in which, that even though the lockdown was effective in decreasing the number of infected agents, people in the facility must do a restriction after to refrain the number of infected agents into rising up again. After day 52 where there were only 44 agents left as susceptible as visualized in figure 4.20, there were only minimal number of susceptible agents and the number of exposed agents continued to drop until day 155 when the transmission already stopped because most of the agents were already either recovered, or dead.

Figure 4.20: Scenario 02.1's first run on day 53. There were few susceptible agents left.

Because the result of the implementation of lockdown gave hope on the possibility that lockdown could potentially minimize and delay the maximum number of exposed agents, the researcher executed another scenario, which was scenario 02.2 where the lockdown was also implemented but on 3rd and 4th weeks of each month to observe if yielded a better result.

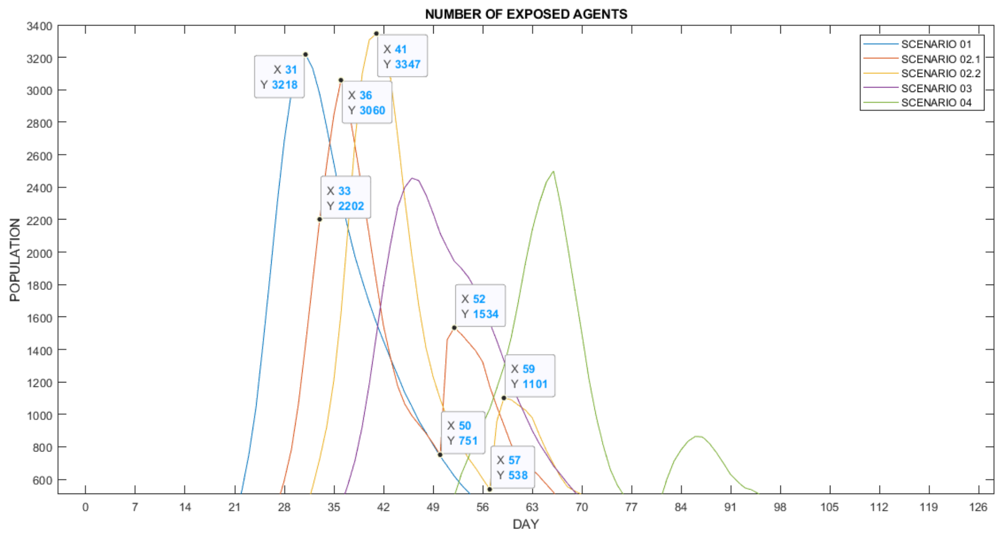

Figure 4.21: The average time series daily chart of the number of Exposed agents in scenarios 1, 2.1, and 2.2 when 5 runs was executed.

Based on figure 4.21, the added scenario which was scenario 02.2 delayed the day where the maximum number of exposed agents have been reached by 10 days compared to the scenario 01 and 5 days compared to scenario 02.1.

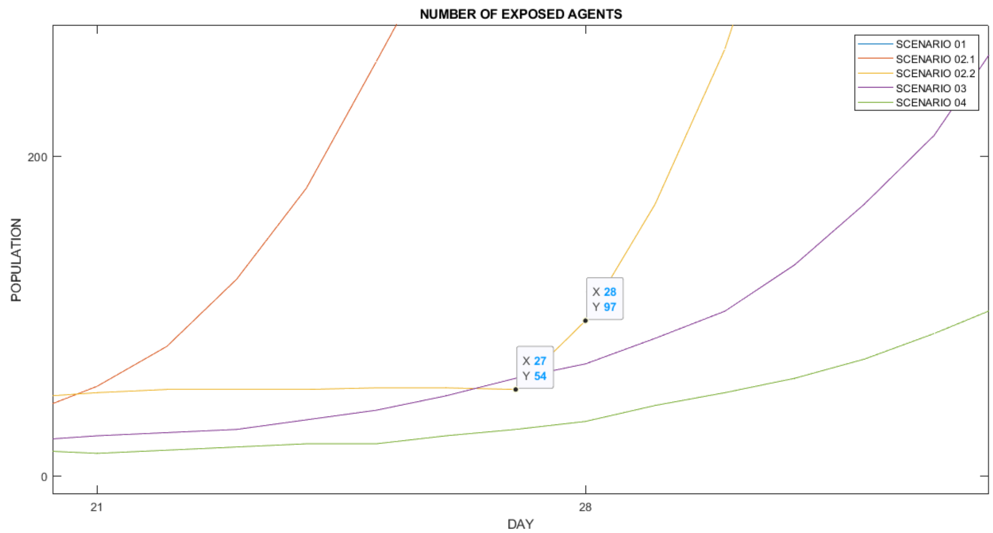

Figure 4.22: The average time series daily chart of the number of Exposed agents in scenario 02.2 day 27 when 5 runs was executed.

This resulted mainly because of the lockdown implemented on days 14-27 which was evident from figure 4.22 because the trend started going up from day 27 with only 54 agents exposed to day 28 where 97 have already been exposed and continued to rise up until the number of exposed agents reached 3347 in day 41. In one day, 43 new exposed agents have been reported which started a day after the last day of lockdown. Again, lockdown could be effective in minimizing the number of exposed agents but since this was only for a given number of days, after the lockdown, restrictions/moderation must still be implemented in order to maintain this trend. Once again in figure 4.21, the trend for scenario 2.2 decreased from day 41 to day 57 and the main reason for this was also the 2nd lockdown that was implemented on days 44 to 57. The trend started to go down on day 41 because there were only minimal number of agents left as susceptible that's why no more agents could be exposed as visualized in figure 4.23 where it almost cannot identify where the small number of susceptible agents were. The same with the behavior of scenario 02.1, the trend accelerated again after the implementation of the lockdown because at day 57, some of the exposed agents became infected and some came back into being susceptible. After lockdown, agents became free to roam again therefore increasing the number of exposed agents once again into 1101 in day 59 then continues to decrease as most of the agents were already infected, recovered, or dead.

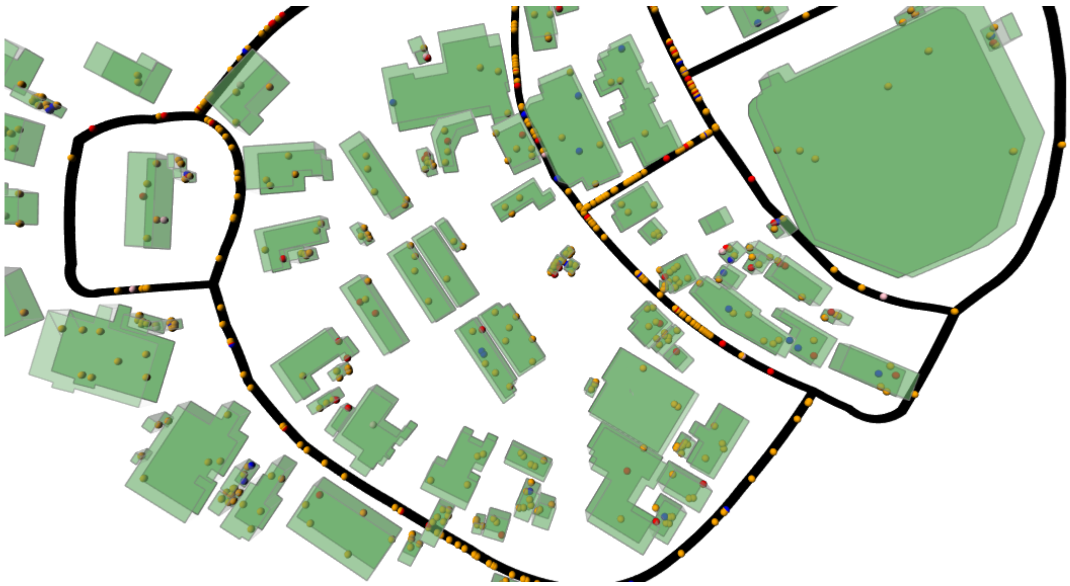

Figure 4.23: Scenario 02.2's first run on day 41. There were few susceptible agents left.

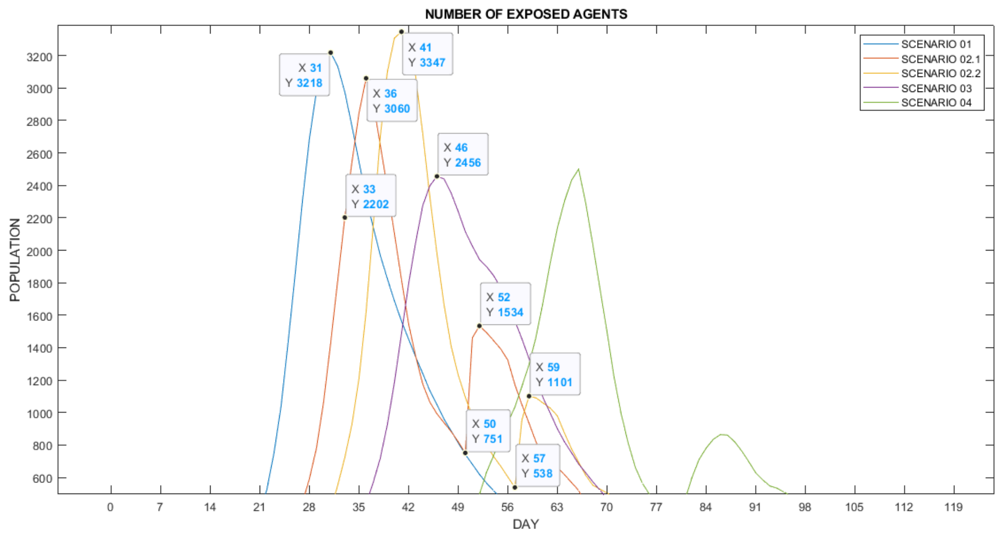

Figure 4.24: The average time series daily chart of the number of Exposed Agents in scenarios 01, 02.1, 02.2, and 03 when 5 runs was executed.

In scenario 02.2, the implementation of lockdown on 3rd and 4th weeks of the month only resulted in delaying the increase in number of exposed agents as compared to scenario 02.1. Even though the lockdown was successful in minimizing the number of exposed agents, after its implementation, restriction must still be followed to avoid the sudden increase again in number of exposed agents. Because of this, the researcher implemented scenario 03 where isolation areas were provided to infected agents so that the risk of transmitting the virus to other agents would lessen. Comparing the result of the execution provided in figure 4.24, the maximum number of exposed agents in scenario 03 was reached at day 46 with 2456 number of agents currently exposed.

The scenario 03 implementation delayed the day where maximum number of exposed agents was reached by 15 days compared to scenario 01, 10 days compared to scenario 02.1, and 5 days compared to scenario 02.2. Aside from this, it also became evident that this implementation was effective in minimizing the number of exposed agents compared to the former scenarios as it only reached 2456 agents as the maximum number of exposed agents compared to 3218 agents in scenario 01, 3060 in scenario 02.1, and 3347 in scenario

02.2. Also, there was no 2nd wave in this scenario meaning the the trend stabilized along the day and continued to decrease the moment the peak has already been reached. From this, the implementation of isolation area for infected agents has been effective in minimizing the number of exposed agents as it also minimized the possible interaction between susceptible and infected agents.

Now that implementing a scheduled lockdown and providing an isolation/quarantine area for the infected agents have been effective in minimizing the number of exposed agents, the researcher combined these two to see if it yield in a better result into minimizing the number of exposed agents.

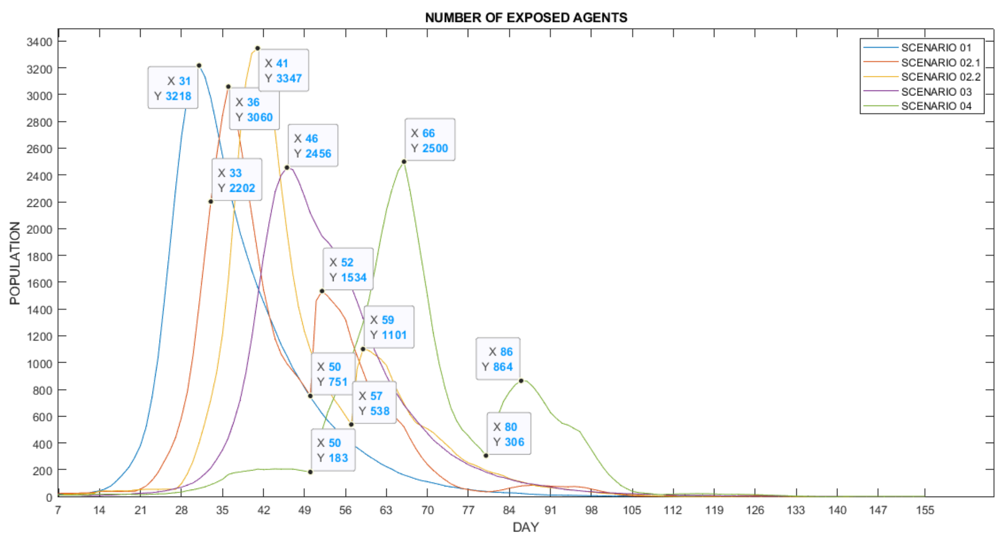

Figure 4.25: The average time series daily chart of the number of Exposed Agents in scenarios 01, 02.1, 02.2, 03, and 04 when 5 runs was executed.

From figure 4.25, when scenario 04 was implemented, the trend only started to increase at day 50 which was very different from the past scenarios as they increased the number of exposed agents the moment the execution started. After 16 days, on day 66, the maximum number of exposed agents have been reached where 2500 agents were currently exposed, delaying this by 35 days compared to scenario 01, 30 days compared to scenario 02.1, 25 days compared to scenario 02.2, and 20 days compared to scenario 03. This was mainly because of the implementation of lockdown and isolation area for infected agents. The trend started going down at day 66 because on days 67-80, lockdown was once again implemented as visualized in figure 4.26 where there was an isolation area provided for infected agents and at the same time scheduled lockdown was being implemented. After the lockdown, a sudden increase have once again became evident resulting in 864 agents into becoming exposed. After this, the trend started to decrease as agents have already been either infected, recovered, or dead.

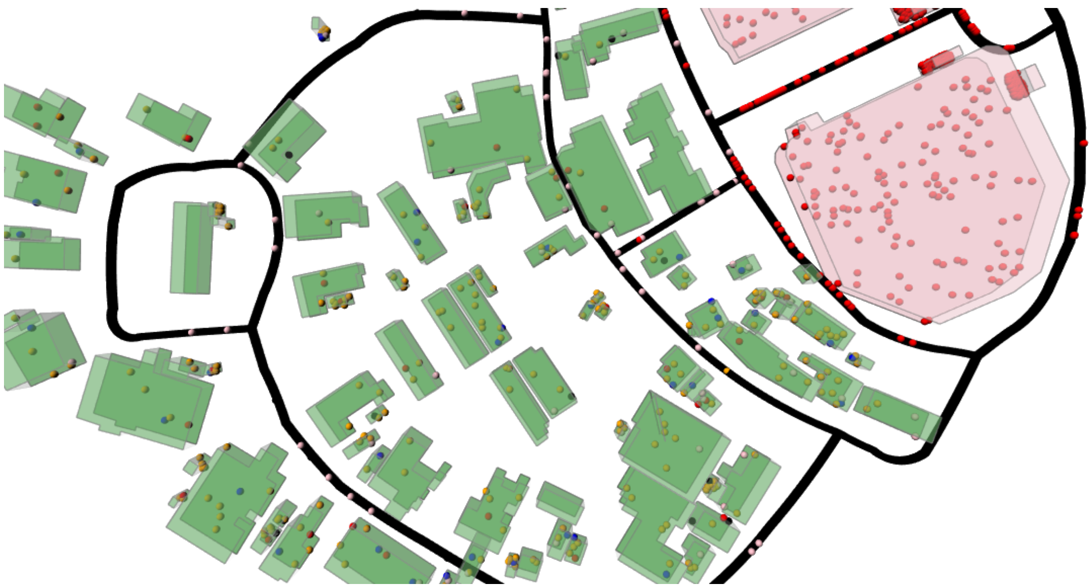

Figure 4.26: Scenario 04 on day 67 of its first run. The infected and recovered agents seen on the road were either going to the isolation area or returning to their assigned buildings.

4.7 Comparing the behavior of the number of Infected agents of all scenarios

In this section, we observed the highest number of current infected agents, which was the peak per scenario and compared the numbers to the other scenarios to observe why and how it happened. Figure 4.27 shows the number of infected agents in the facility, from day 01, the first day with 0 number of exposed agents to day 156, the last day when it went back into 0 number of infected agents.

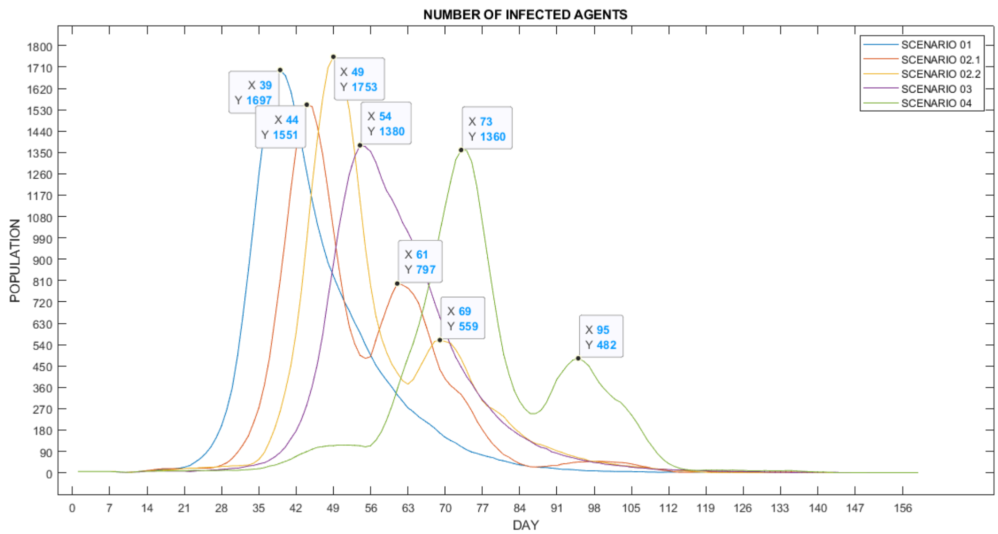

Figure 4.27: The average time series daily chart of the number of Infected agents in all scenarios when 5 runs was executed.

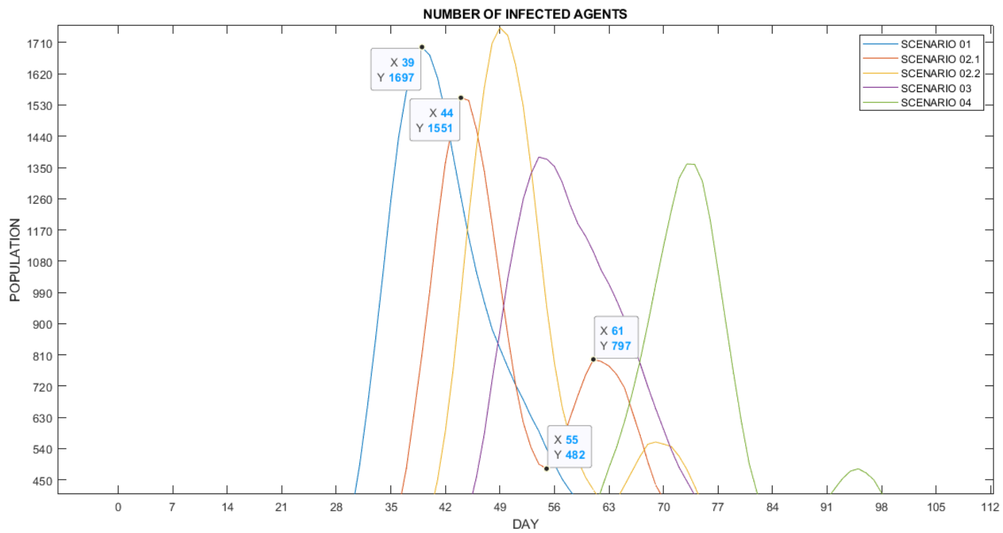

Figure 4.28: The average time series daily chart of the number of Infected agents in scenario 01 and 02.1 when 5 runs was executed.

Starting from scenario 01, the most number of infected agents was reached at day 39 with 1697 agents infected at this day. In scenario 02.1, the most number of infected agents was reached at day 44 with 1551 agents infected at this day. Refer to figure 4.28, the only difference between scenarios 1 and 2.1 on days 1-44 was the implementation of 14-day scheduled lockdown of scenario 2.1 on days 7-20 and day 37-50 which resulted on the delay of reaching the maximum number of infected agents by 5 days and lowering this number by 146 agents. The trend for the number of exposed agents in figure 4.17 was observed. For scenario 01, it only lasted 8 days from day 31 to day 39 for the maximum number of infected agents to reach its peak after the number of exposed agents reached its peak. For scenario 02.1, it took 8 days from day 36 to day 44 for the maximum number of infected agents to reach its peak after the number of exposed agents reached its peak. Also, after day 44 for scenario 02.1, the number of infected agents decreased until day 55 which was a reflection of the behavior in the number of exposed agents for scenario 02.1 as it also decreased on day 37 which was the 1st day of the implementation of lockdown. Therefore, the decrease in the number of infected agents on days 44-55 was a result of the 2nd lockdown being implemented in scenario 02.1 in which we could predict based on the decrease in the number of exposed agents from day 37-50 that the implementation of lockdown gave a favorable result in minimizing not just the number of exposed agents but as well as the potential number of infected agents during the execution. Unfortunately, after day 55, the number of infected agents once again increased mainly because as an effect of the end of lockdown on day 50 where the number of exposed agents also went up.

As a result, another wave became evident once again increasing the number of newly infected agents on these days which showed even though the lockdown was effective in decreasing the number of exposed and infected agents, people inside the facility still must do a restriction after to refrain the number of infected agents into rising up again. After day 61 where there were 797 currently infected agents, the number of infected agents continued to drop until day 140 when the transmission already stopped because most of the agents were already either recovered, or dead.

Because the researcher saw that lockdown could potentially minimize and delay the maximum number of infected agents, another scenario was executed where the lockdown was also implemented but on 3rd and 4th weeks of each month to observe if it could yield in a better result.

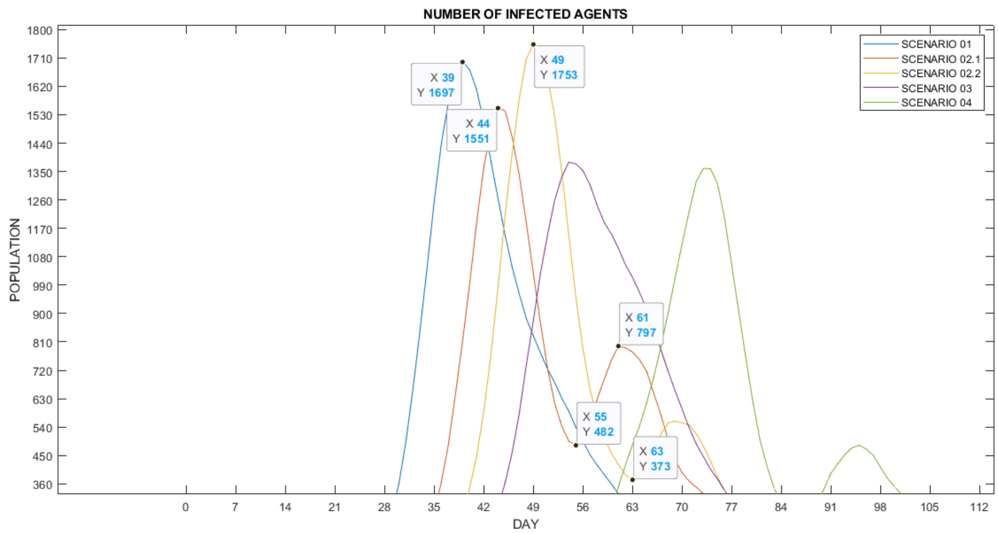

Figure 4.29: The average time series daily chart of Infected agents in scenarios 1, 2.1, and 2.2 when 5 runs was executed.

As observed in figure 4.29, scenario 02.2 delayed the day where the maximum number of infected agents have been reached by 10 days compared to the scenario 01 and 5 days from scenario 02.1 which resulted in a similar behavior when we analyzed the behavior of the number of exposed agents in each scenario.

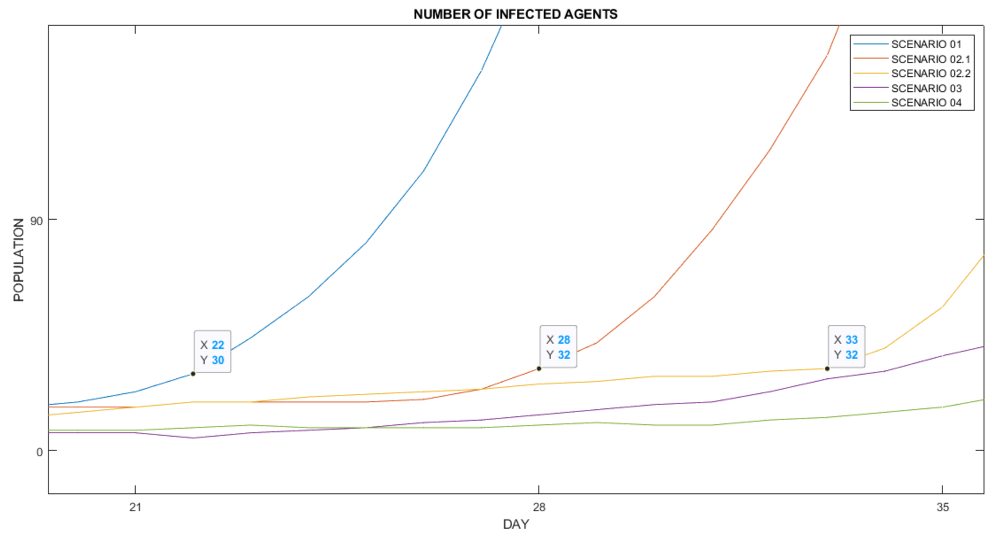

Figure 4.30: The average time series daily chart when each scenario reached 30 infected agents.

Day 22 was the day when the scenario 01 reached 30 infected agents, day 28 for scenario 02.1, and day 33 for scenario 02.2 and this resulted mainly because of the lockdown implemented on days 7-20 for scenario 02.1 and days 14-27 for scenario 02.1 which was evident from figure 4.30 because the trend started going up on different days and continued to rise up until the maximum number of infected agents have already been reached and again, went down and increased again as an effect of the release of lockdown for scenarios 2.1 and 2.2 which were days only after the number of exposed agents once again increased. Again, the number of exposed agents reflected and predicted the behavior of the potential number of infected agents and scheduled lockdown were effective in minimizing these numbers but since this was only for a given number of days, after the lockdown, restrictions/moderation must still be implemented in order to maintain this trend. Once again in figure 4.29, the trend for scenario 2.2 decreased from day 49 to day 63 and the main reason for this was also the 2nd lockdown that was implemented on days 44 to 57 in which on these days, the number of exposed agents decreased which predicted the behavior of the number of infected agents 5 days after the start of the lockdown. The trend started to go down on day 49 as a reflection as the number of exposed agents also went down on day 44. The same with the behavior of scenario 02.1, the trend accelerated again as a result after the implementation of the scheduled lockdown. After lockdown, agents became free to roam again therefore increasing the number of exposed and infected agents. Once again, the number of infected agents rised into 797 in day 61 for scenario 02.1 and 559 in day 69 for scenario 02.2 then continued to decrease as most of the agents were already either recovered, or dead.

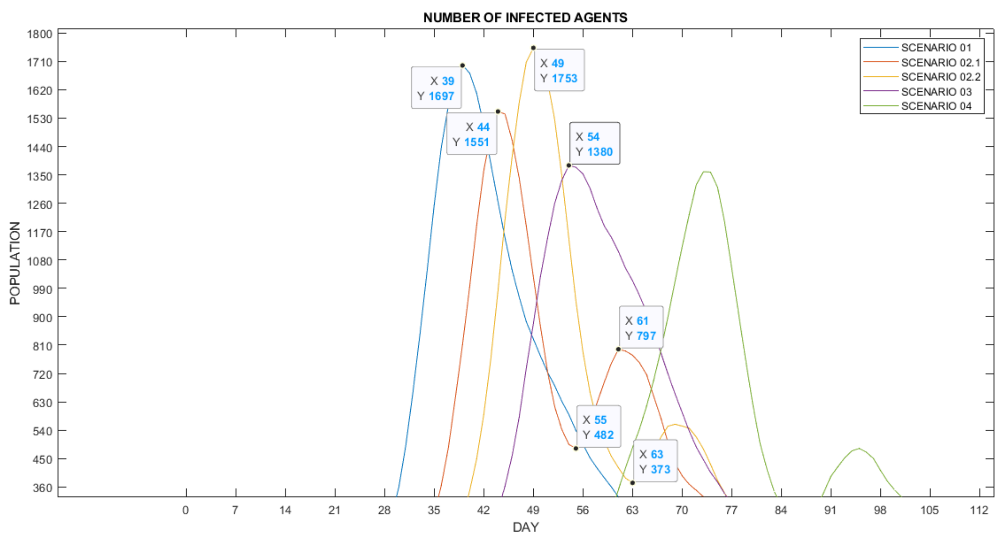

Figure 4.31: The average time series daily chart of the number of Infected agents in scenarios 01, 02.1, 02.2, and 03 when 5 runs was executed.

The implementation of lockdown in 3rd and 4th weeks of the month only resulted in delaying the increase in number of infected agents as a reflection in increased of the number of exposed agents as well when compared to scenario 02.1. Also, scenario 02.2 lead to a worse result compared to scenario 02.1 since the maximum number of infected agents became higher and started to reach and expose all the remaining agents after the end of lockdown. By implementing a lockdown when the number of infected agents were high which what happened in scenario 02.2 where it was visualized in figure 4.32, tendency was that the infected agents and susceptible was trapped together in a building which made it riskier for agents to get infected since during lockdown, movements were very limited hence, the more chance an agent could get exposed and infected as visualized at figure 4.33.

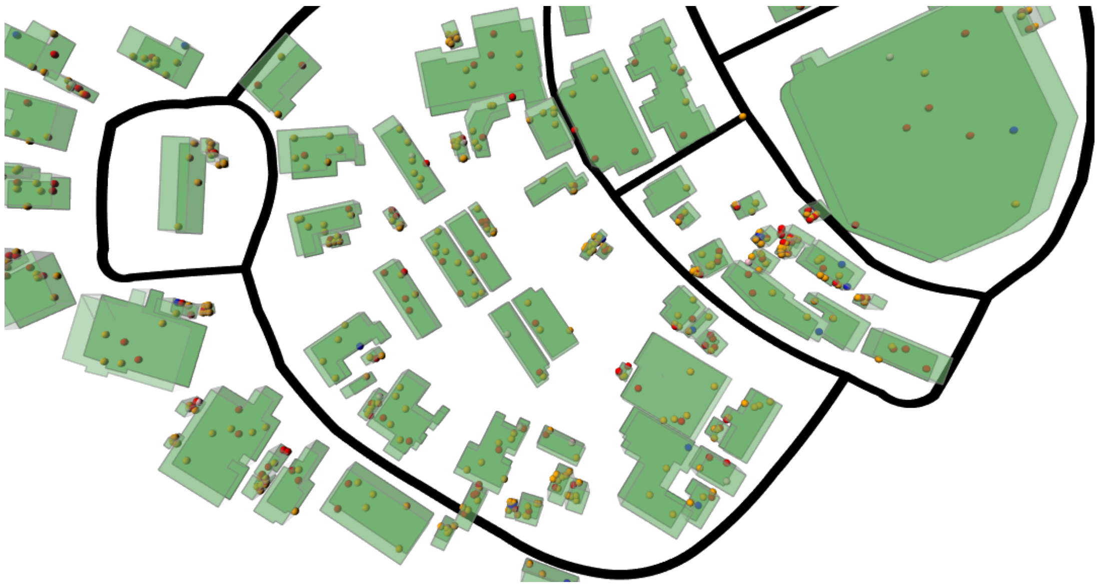

Figure 4.32: On day 44 of scenario 02.2's initial run, numerous infected agents were locked down.

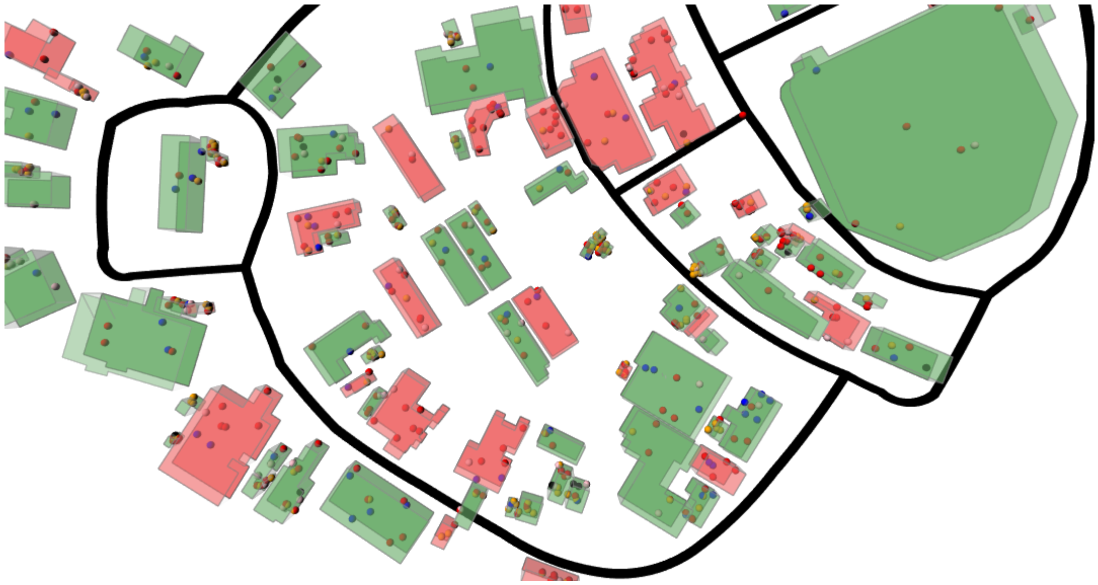

Figure 4.33: Scenario 02.2's first run on day 50, the last day of lockdown. Infected agents already outnumbered non-infected agents in red buildings.

The earlier the lockdown was implemented, the better it could result in minimizing the number of potential agents that could be infected therefore implementing scenario 02.1 could yield in a more favorable result compared to implementing scenario 02.2. Even though the lockdown was successful in minimizing the number of exposed and infected agents, after its implementation, restriction must still be followed to avoid the sudden increase again in number of exposed and infected agents. Because of this, the researcher implemented the scenario 03 where isolation areas were provided to infected agents so that the risk of transmitting the virus to other agents would lessen. Comparing the result of the execution provided in figure 4.31, the maximum number of infected agents in scenario 03 was reached at day 54 with 1380 number of agents currently infected.

The scenario 03 implementation delayed the day where maximum number of infected agents was reached by 15 days compared to scenario 01, 10 days compared to scenario 02.1, and 5 days compared to scenario 02.2. Aside from this, it also became evident that this implementation was effective in minimizing the number of infected agents compared to the former scenarios as it only reached a 1380 as the maximum number of exposed agents compared to 1697 in scenario 01, 1551 in scenario 02.1, and 1753 in scenario 02.2.

Also, there was no 2nd wave in this scenario meaning the the trend stabilized along the day and continued to decrease the moment the peak has already been reached. The implementation of isolation area for infected agents has been effective in minimizing the number of newly infected agents as it also minimized the possible interaction between susceptible and infected agents.

Now that implementing a lockdown and providing an isolation/quarantine area for the infected agents have been effective in minimizing the number of infected agents, the researcher combined these two to see if it will yield a better result into minimizing the number of infected agents.

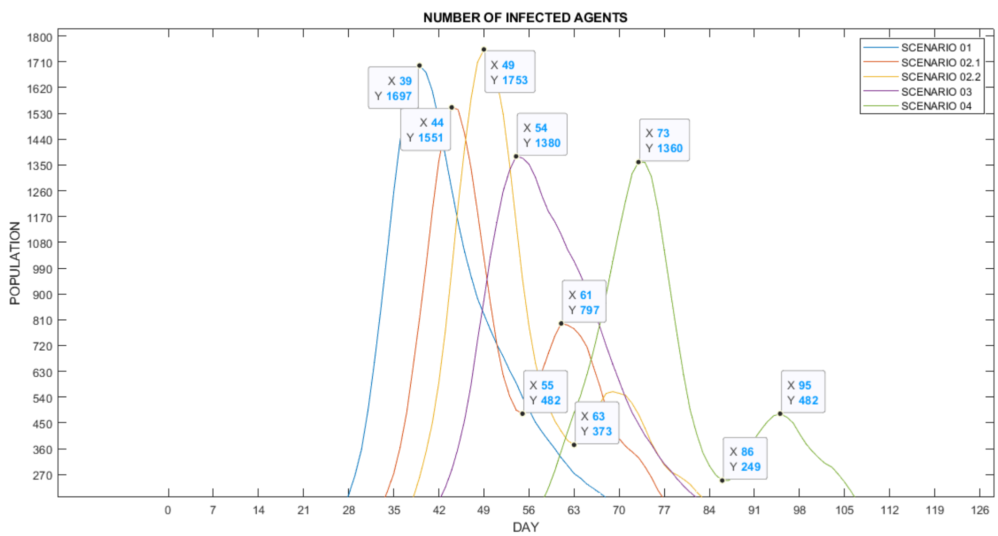

Figure 4.34: The average time series daily chart of the number of Infected agents in scenarios 01, 02.1, 02.2, 03, and 04 when 5 runs was executed.

From figure 4.34, when scenario 04 was implemented, the trend only started to increase at day 55 which was very different from the past scenarios as they increase the number of infected agents 7-10 days after the execution started. Also, this has became a reflection when the number of exposed agents in this scenario started to increase at day 50. After 18 days, on day 73, the maximum number of infected agents have been reached where 1360 agents were currently infected, delaying this by 34 days compared to scenario 01, 29 days compared to scenario 02.1, 24 days compared to scenario 02.2, and 19 days compared to scenario 03. This was mainly because of the implementation of lockdown and isolation area for infected agents. The trend started going down at day 73 because on days 67-80, lockdown was once again implemented and this has became a reflection of the effectiveness of implementing a lockdown. After day 87, 7 days after the end of a lockdown, a sudden increase have once again became evident resulting in 482 agents into becoming infected. After this, the trend started to decrease as agents have already been either recovered, or dead.

The number of exposed agents could predict the possible number of infected agents and that implementing lockdown and isolation area for the infected agents could not just delay the number of days where the maximum number of agents can be infected but as well as minimize the number of infected agents which could therefore result in a lower virus transmission risk.

4.8 Comparing the behavior of the number of Affected (Infected + Recovered + Dead) Agents of all scenarios

From the number of infected agents, when comparing scenario 02.2 from scenario 02.1, implementing scenario 02.1 could yield in a more favorable result compared to scenario 02.2 because the earlier the lockdown was implemented, the faster it could restrict the agents from socializing with the others. If the facility would implement a lockdown when the number of infected agents are high, tendency was that the infected agents and susceptible will be trapped together in a building which made it riskier for agents to get infected since during lockdown, movements were very limited hence, the more chance an agent could get exposed and infected which was visualized in figure 4.32. With that, in this section, the researcher considered scenario 02.1 alone when comparing with other scenarios since the only difference from scenario 02.1 and scenario 02.2 was the day when the start of the scheduled lockdown was implemented.

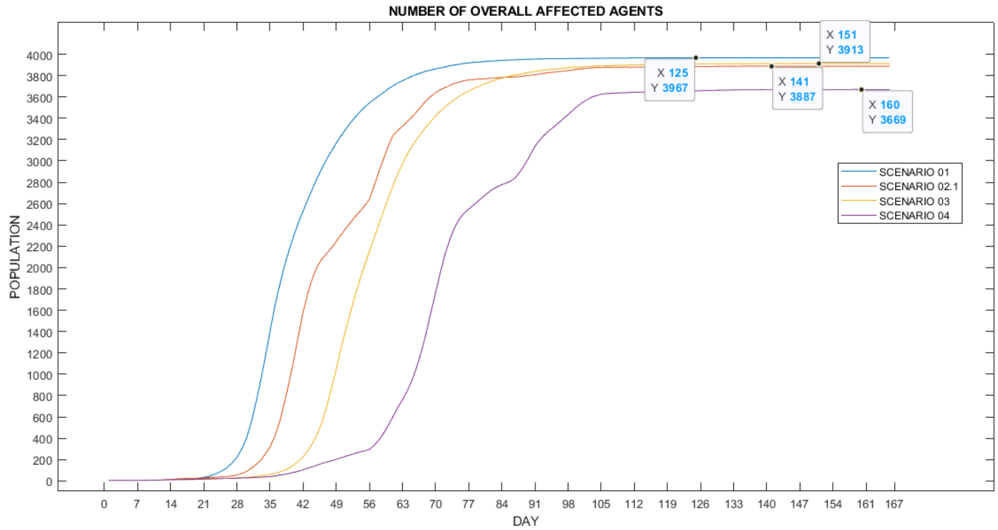

Figure 4.35: The average time series daily chart of the number of Affected agents in all scenarios when 5 runs was executed.

The researcher compared the overall number of the agents that has became affected throughout the execution and compared the numbers to the other scenarios so that it could observe which scenario has the most and least number of overall affected agents from day 01 to the day each scenario's line has flattened, meaning the virus transmission has ended.

The researcher computed for its rate of change or the slope of the linear function. To find the slope, two points was considered which was the starting point at day 01 when there were only 5 infected agents (x_1, y_1) and the point where the maximum number of overall agents was reached (x_2, y_2) in which was visualized at figure 4.35. The rate of change between two points was given by this formula:

$$\text{Average Rate of Change} = \frac{\Delta y}{\Delta x} = \frac{y_2 - y_1}{x_2 - x_1}$$

For scenario 01, the first case of affected agent was recorded on day 1 where 5 agents have been infected $(1, 5)$ and the maximum number of affected agents was reached at day 125 where 3967 agents were currently exposed $(125, 3967)$. The rate of change in number of exposed agents for this scenario was

$$\text{Increase Rate of Change} = \frac{\Delta y}{\Delta x} = \frac{3967-5}{125-1}$$
$$\approx 32 \text{ agents per day}$$

For scenario 02.1, the first case of affected agent was recorded on day 1 where 5 agents have been infected $(1, 5)$ and the maximum number of exposed agents was reached at day 141 where 3887 agents were currently exposed $(36, 3060)$. The rate of change in number of exposed agents for this scenario was

$$\text{Increase Rate of Change} = \frac{\Delta y}{\Delta x} = \frac{3887-5}{141-1}$$
$$\approx 28 \text{ agents per day}$$

For scenario 03, the first case of affected agent was recorded on day 1 where 5 agents have been infected $(1, 5)$ and the maximum number of exposed agents was reached at day 151 where 3913 agents was currently exposed $(151, 3913)$. The rate of change in number of exposed agents for this scenario was

$$\text{Increase Rate of Change} = \frac{\Delta y}{\Delta x} = \frac{3913-5}{151-1}$$
$$\approx 26 \text{ agents per day}$$

For scenario 04, the first case of affected agent was recorded on day 1 where 5 agents have been infected $(1, 5)$ and the maximum number of exposed agents was reached at day 160 where 3669 agents was currently exposed $(160, 3669)$. The rate of change in number of exposed agents for this scenario was

$$\text{Increase Rate of Change} = \frac{\Delta y}{\Delta x} = \frac{3669-5}{160-1}$$
$$\approx 23 \text{ agents per day}$$

The overall affected agents, which means that the ones who became infected then recovered or died in a span on 167 days when scenario 01 was implemented was 3967 agents or 99.175% of the overall population of the facility.

When scenario 02.1 was implemented, which was the implementation of scheduled lockdown on 2nd and 3rd weeks of the month, the number of overall affected agents went down into 3887 or 97.175 of the overall population which proved that the implementation of scenario 02.1 gave an affirmative effect on lowering the Virus Transmission Risk inside the facility by 80 agents compared to scenario 01.

When scenario 03 was implemented, which was the implementation of Isolation Area for the Infected Agents, the number of overall affected agents went down into 3913 or 97.825 of the overall population which proved that the implementation of scenario 03 also gave an affirmative effect on lowering the Virus Transmission Risk inside the facility by 54 agents compared to scenario 01 and is only higher by 26 agents compared to scenario 02.1. Seeing that both moderation was effective in minimizing the Virus Transmission Risk, the researcher combined these two and predicted the possible outcome on how many agents could be affected by the end of the execution.

When scenario 04 was implemented, which was the implementation of both scheduled lockdown and isolation area for the Infected agents, the number of overall affected agents went down into 3669 or 91.725 of the overall population which proved that the implementation of scenario 04 really gave an affirmative effect on lowering the Virus Transmission Risk inside the facility and is by far the most effective way of minimizing the possible number of affected agents. The number lowered by 298 agents compared to scenario 01, lowered by 218 compared to scenario 02.1, and 244 compared to scenario 03.

Chapter 5

Conclusion and Recommendation

According to preliminary findings, the suggested experimental models can provide a very flexible tool for public health decision-makers to evaluate various control approaches in order to prevent the spread of COVID 19 inside the National Center For Mental Health (NCMH). Out of all the 4000 population inside the facility where 5 were initially infected, approximately 99.18% were affected by the virus when no moderation was applied, approximately 97.18% were affected by the virus when a scheduled 14-days lockdown each month was applied, approximately 97.83% were affected by the virus when an isolation area for the infected agents were provided, and approximately 91.73% were affected by the virus when the combined implementation of a scheduled 14-day lockdown and providing a quarantine area for the infected agents was applied.

Though the effect of each applied moderation varies, all of it was effective in minimizing the potential number of not just the infected agents but as well as the overall affected agents during the execution. The combined implementation of a scheduled 14-day lockdown and providing a quarantine area for the infected agents gave an affirmative effect and most favorable result on lowering the COVID 19 transmission risk inside the facility by approximately 10% compared to the basic experiment where no moderation was applied.

Overall, the findings of this study provide important insights into the relationship between the COVID 19 Disease and the behavior of the people inside the facility and highlights the need for further research in this area. For the next study, I recommend the researcher to execute a scenario where stricter rules will be implemented and consider running the experiment for several times before taking the average for a more accurate result. Also, the researcher could take into account the ages of the agents inside the facility and observe the transmission risk when different age groups were inside the facility.

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Appendix A

Table for Scenario 01

Day	Population	Susceptible	Exposed	Infected	Recovered	Dead
1	4000	3995	0	5	0	0
2	4000	3995	2	5	0	0
3	4000	3995	3	5	0	0
4	4000	3995	9	5	0	0
5	4000	3995	10	5	0	0
6	4000	3995	11	5	0	0
7	4000	3995	19	5	0	0
8	4000	3994	22	6	0	0
9	3999	3994	25	4	1	1
10	3999	3993	24	2	4	1
11	3999	3991	27	4	4	1
12	3999	3990	33	5	4	1
13	3999	3987	47	8	4	1
14	3999	3986	70	9	4	1
15	3999	3984	90	11	4	1
16	3999	3981	112	13	5	1
17	3999	3977	159	17	5	1
18	3999	3977	235	16	6	1
19	3999	3974	306	19	6	1
20	3999	3969	401	22	8	1

Day	**Population**	**Susceptible**	**Exposed**	**Infected**	**Recovered**	**Dead**
21	3997	3962	533	27	8	3
22	3996	3947	752	40	9	4
23	3996	3930	1008	55	11	4
24	3996	3908	1421	75	13	4
25	3996	3876	1961	105	15	4
26	3996	3839	2542	139	18	4
27	3995	3772	3084	204	19	5
28	3995	3689	3376	284	22	5
29	3994	3593	3447	374	27	6
30	3990	3476	3359	479	35	10
31	3988	3292	3190	649	47	12
32	3984	3049	2971	870	65	16
33	3979	2792	2725	1102	85	21
34	3968	2521	2477	1328	119	32
35	3958	2272	2241	1525	161	42
36	3946	2062	2041	1668	216	54
37	3928	1916	1897	1730	282	72
38	3899	1777	1767	1747	375	101
39	3874	1656	1645	1732	486	126
40	3815	1536	1524	1631	648	185
41	3777	1403	1382	1552	822	223
42	3737	1284	1269	1406	1047	263
43	3688	1175	1157	1250	1263	312
44	3646	1071	1055	1138	1437	354
45	3617	971	955	1054	1592	383
46	3585	895	877	978	1712	415
47	3559	816	796	922	1821	441
48	3525	757	746	841	1927	475
49	3496	686	668	791	2019	504
50	3472	628	601	724	2120	528

Day	Population	Susceptible	Exposed	Infected	Recovered	Dead
51	3455	575	549	664	2216	545
52	3437	531	506	602	2304	563
53	3423	482	458	555	2386	577
54	3411	445	427	499	2467	589
55	3400	399	379	464	2537	600
56	3392	382	355	417	2593	608
57	3374	357	324	364	2653	626
58	3362	328	300	340	2694	638
59	3348	296	267	320	2732	652
60	3336	261	234	303	2772	664
61	3321	238	215	268	2815	679
62	3308	226	197	237	2845	692
63	3299	209	186	214	2876	701
64	3292	196	168	199	2897	708
65	3286	183	153	184	2919	714
66	3279	159	132	178	2942	721
67	3275	141	115	172	2962	725
68	3265	128	102	154	2983	735
69	3258	116	91	139	3003	742
70	3256	109	84	129	3018	744
71	3250	101	80	118	3031	750
72	3247	94	75	114	3039	753
73	3243	89	67	96	3058	757
74	3239	82	58	83	3074	761
75	3238	75	52	78	3085	762
76	3235	69	47	69	3097	765
77	3235	65	41	60	3110	765
78	3235	60	38	56	3119	765
79	3232	53	28	53	3126	768
80	3230	50	27	46	3134	770

Day	Population	Susceptible	Exposed	Infected	Recovered	Dead
81	3230	47	27	44	3139	770
82	3227	46	27	40	3141	773
83	3226	45	25	33	3148	774
84	3224	44	26	26	3154	776
85	3224	42	25	27	3155	776
86	3224	39	19	24	3161	776
87	3223	35	14	23	3165	777
88	3223	30	11	23	3170	777
89	3222	29	11	23	3170	778
90	3222	29	12	19	3174	778
91	3221	27	10	19	3175	779
92	3221	27	9	17	3177	779
93	3221	26	10	18	3177	779
94	3221	25	9	16	3180	779
95	3220	25	8	12	3183	780
96	3219	25	7	6	3188	781
97	3219	25	6	4	3190	781
98	3219	24	6	5	3190	781
99	3219	23	4	5	3191	781
100	3219	23	4	3	3193	781
101	3219	22	3	4	3193	781
102	3219	22	2	3	3194	781
103	3219	22	2	3	3194	781
104	3219	22	2	3	3194	781
105	3219	22	3	3	3194	781
106	3219	22	3	2	3195	781
107	3219	22	3	2	3195	781
108	3219	21	2	2	3196	781
109	3219	21	2	1	3197	781
110	3219	21	2	1	3197	781

Day	Population	Susceptible	Exposed	Infected	Recovered	Dead
111	3219	20	1	2	3197	781
112	3219	20	1	2	3197	781
113	3219	20	0	2	3197	781
114	3219	20	0	2	3197	781
115	3219	20	0	2	3197	781
116	3218	20	0	1	3197	782
117	3218	20	0	1	3197	782
118	3218	20	1	1	3197	782
119	3218	20	1	1	3197	782
120	3218	20	1	1	3197	782
121	3217	20	1	0	3197	783
122	3217	20	1	0	3197	783
123	3217	20	1	0	3197	783

Table A.1: Run 01: Time series table of the total number of population, susceptible, exposed, infected, recovered, and dead agents from day 1, the start of execution to day 123, when the number of exposed and infected agents became 0.

Day	Population	Susceptible	Exposed	Infected	Recovered	Dead
0	4000	3995	0	5	0	0
1	4000	3995	0	5	0	0
2	4000	3995	0	5	0	0
3	4000	3995	1	5	0	0
4	4000	3995	3	5	0	0
5	4000	3995	8	5	0	0
6	4000	3995	14	5	0	0
7	4000	3995	21	5	0	0
8	4000	3995	23	4	1	0
9	3999	3995	23	2	2	1
10	3999	3995	22	1	3	1
11	3999	3995	19	0	4	1
12	3999	3993	17	2	4	1
13	3999	3992	19	3	4	1
14	3999	3989	21	6	4	1
15	3999	3987	26	8	4	1
16	3999	3984	38	11	4	1
17	3999	3983	71	12	4	1
18	3999	3983	98	12	4	1
19	3999	3982	132	12	5	1
20	3999	3981	179	13	5	1

Day	**Population**	**Susceptible**	**Exposed**	**Infected**	**Recovered**	**Dead**
21	3998	3977	238	14	7	2
22	3998	3973	294	17	8	2
23	3997	3961	404	27	9	3
24	3997	3953	527	33	11	3
25	3996	3937	823	47	12	4
26	3995	3920	1125	63	12	5
27	3995	3898	1633	85	12	5
28	3995	3860	2291	121	14	5
29	3995	3821	2861	159	15	5
30	3995	3773	3269	201	21	5
31	3994	3685	3456	281	28	6
32	3990	3569	3426	386	35	10
33	3988	3408	3280	533	47	12
34	3984	3183	3087	743	58	16
35	3980	2900	2843	1011	69	20
36	3976	2619	2553	1266	91	24
37	3968	2383	2345	1468	117	32
38	3955	2177	2158	1621	157	45
39	3937	2027	2005	1694	216	63
40	3911	1874	1851	1746	291	89
41	3884	1749	1741	1733	402	116
42	3845	1639	1625	1672	534	155
43	3803	1523	1509	1542	738	197
44	3757	1409	1386	1402	946	243
45	3698	1288	1267	1257	1153	302
46	3657	1190	1170	1131	1336	343
47	3612	1090	1073	1036	1486	388
48	3583	1011	990	960	1612	417
49	3557	942	924	891	1724	443
50	3534	854	839	868	1812	466

Day	Population	Susceptible	Exposed	Infected	Recovered	Dead
51	3503	777	755	810	1916	497
52	3478	710	683	780	1988	522
53	3449	659	639	697	2093	551
54	3430	621	597	636	2173	570
55	3416	573	555	582	2261	584
56	3401	523	497	546	2332	599
57	3391	474	451	520	2397	609
58	3379	431	403	480	2468	621
59	3363	400	375	440	2523	637
60	3352	365	341	400	2587	648
61	3341	334	318	363	2644	659
62	3331	307	293	338	2686	669
63	3320	281	260	318	2721	680
64	3310	258	243	289	2763	690
65	3300	229	202	271	2800	700
66	3289	205	174	255	2829	711
67	3282	192	168	230	2860	718
68	3276	171	148	214	2891	724
69	3274	156	134	198	2920	726
70	3269	142	122	183	2944	731
71	3262	128	108	167	2967	738
72	3258	117	98	160	2981	742
73	3247	109	90	134	3004	753
74	3241	98	78	123	3020	759
75	3236	89	70	109	3038	764
76	3234	79	53	98	3057	766
77	3232	74	54	94	3064	768
78	3229	72	49	76	3081	771
79	3228	66	41	72	3090	772
80	3227	64	35	62	3101	773

Day	Population	Susceptible	Exposed	Infected	Recovered	Dead
81	3225	60	30	59	3106	775
82	3224	57	30	50	3117	776
83	3222	54	27	41	3127	778
84	3218	51	24	35	3132	782
85	3216	51	24	26	3139	784
86	3216	47	20	25	3144	784
87	3216	45	16	23	3148	784
88	3215	44	12	22	3149	785
89	3215	42	8	23	3150	785
90	3213	40	4	19	3154	787
91	3213	40	6	16	3157	787
92	3213	38	4	13	3162	787
93	3212	38	5	11	3163	788
94	3212	38	6	9	3165	788
95	3212	37	4	9	3166	788
96	3212	37	6	9	3166	788
97	3212	36	5	6	3170	788
98	3212	36	5	5	3171	788
99	3212	36	5	4	3172	788
100	3212	35	4	4	3173	788
101	3212	35	3	3	3174	788
102	3212	35	2	2	3175	788
103	3212	35	3	2	3175	788
104	3212	35	2	2	3175	788
105	3212	35	2	2	3175	788
106	3212	34	2	3	3175	788
107	3212	34	2	2	3176	788
108	3212	34	2	1	3177	788
109	3212	34	2	1	3177	788
110	3212	34	2	1	3177	788

Day	Population	Susceptible	Exposed	Infected	Recovered	Dead
111	3212	34	2	1	3177	788
112	3212	34	0	1	3177	788
113	3212	34	0	1	3177	788
114	3212	34	1	1	3177	788
115	3212	34	1	0	3178	788
116	3212	34	1	0	3178	788
117	3212	34	1	0	3178	788
118	3212	34	1	0	3178	788
119	3212	34	1	0	3178	788
120	3212	34	0	0	3178	788

Table A.2: Run 02: Time series table of the total number of population, susceptible, exposed, infected, recovered, and dead agents from day 1, the start of execution to day 120, when the number of exposed and infected agents became 0.

Day	Population	Susceptible	Exposed	Infected	Recovered	Dead
1	4000	3995	0	5	0	0
2	4000	3995	2	5	0	0
3	4000	3995	3	5	0	0
4	4000	3995	5	5	0	0
5	4000	3995	7	5	0	0
6	4000	3995	12	5	0	0
7	4000	3995	16	5	0	0
8	4000	3995	19	5	0	0
9	3998	3994	22	4	0	2
10	3997	3994	23	1	2	3
11	3997	3993	23	2	2	3
12	3997	3992	21	3	2	3
13	3997	3990	25	5	2	3
14	3997	3988	24	7	2	3
15	3997	3984	39	11	2	3
16	3997	3981	70	14	2	3
17	3997	3980	96	14	3	3
18	3997	3980	122	14	3	3
19	3997	3976	160	18	3	3
20	3997	3975	214	17	5	3

Day	Population	Susceptible	Exposed	Infected	Recovered	Dead
21	3997	3968	279	23	6	3
22	3996	3960	406	27	9	4
23	3996	3949	619	38	9	4
24	3996	3933	848	52	11	4
25	3996	3917	1232	66	13	4
26	3994	3897	1716	82	15	6
27	3994	3865	2289	112	17	6
28	3993	3830	2854	146	17	7
29	3992	3761	3232	212	19	8
30	3990	3665	3415	301	24	10
31	3985	3519	3374	432	34	15
32	3984	3338	3232	602	44	16
33	3980	3130	3051	794	56	20
34	3979	2903	2823	1003	73	21
35	3976	2626	2572	1257	93	24
36	3970	2365	2332	1474	131	30
37	3965	2141	2114	1647	177	35
38	3951	1966	1947	1743	242	49
39	3929	1819	1803	1789	321	71
40	3900	1705	1690	1752	443	100
41	3860	1591	1573	1676	593	140
42	3810	1488	1470	1554	768	190
43	3760	1379	1357	1424	957	240
44	3706	1299	1273	1238	1169	294
45	3651	1189	1160	1095	1367	349
46	3620	1097	1078	997	1526	380
47	3585	1010	983	909	1666	415
48	3562	934	915	851	1777	438
49	3542	857	837	820	1865	458
50	3519	801	773	762	1956	481

Day	Population	Susceptible	Exposed	Infected	Recovered	Dead
51	3496	736	719	721	2039	504
52	3476	668	644	682	2126	524
53	3453	606	583	650	2197	547
54	3428	561	539	602	2265	572
55	3407	509	477	549	2349	593
56	3393	477	456	492	2424	607
57	3379	446	413	456	2477	621
58	3364	413	393	420	2531	636
59	3355	377	350	397	2581	645
60	3343	341	321	375	2627	657
61	3328	312	292	333	2683	672
62	3316	277	261	309	2730	684
63	3305	256	230	283	2766	695
64	3299	239	212	270	2790	701
65	3287	218	183	240	2829	713
66	3280	196	176	231	2853	720
67	3275	187	161	212	2876	725
68	3271	167	136	197	2907	729
69	3263	156	125	176	2931	737
70	3256	151	125	147	2958	744
71	3249	142	111	128	2979	751
72	3245	133	99	119	2993	755
73	3244	119	90	114	3011	756
74	3242	113	86	96	3033	758
75	3240	106	82	87	3047	760
76	3236	98	70	82	3056	764
77	3234	94	67	72	3068	766
78	3231	87	55	70	3074	769
79	3229	85	51	64	3080	771
80	3225	81	47	58	3086	775

Day	Population	Susceptible	Exposed	Infected	Recovered	Dead
81	3223	77	41	53	3093	777
82	3223	74	33	48	3101	777
83	3222	71	28	41	3110	778
84	3222	69	27	38	3115	778
85	3222	67	27	34	3121	778
86	3222	66	27	26	3130	778
87	3220	64	25	26	3130	780
88	3219	62	21	22	3135	781
89	3219	62	20	22	3135	781
90	3216	62	21	14	3140	784
91	3216	60	17	13	3143	784
92	3215	59	16	10	3146	785
93	3215	58	14	10	3147	785
94	3215	55	12	13	3147	785
95	3215	55	11	11	3149	785
96	3215	55	9	10	3150	785
97	3213	55	8	8	3150	787
98	3213	55	7	7	3151	787
99	3213	55	7	6	3152	787
100	3213	53	3	8	3152	787
101	3213	53	1	7	3153	787
102	3213	53	1	4	3156	787
103	3213	53	1	3	3157	787
104	3213	52	1	3	3158	787
105	3213	52	1	3	3158	787
106	3213	52	1	3	3158	787
107	3213	52	1	3	3158	787
108	3213	52	1	3	3158	787
109	3213	52	1	1	3160	787
110	3213	52	1	1	3160	787

Day	**Population**	**Susceptible**	**Exposed**	**Infected**	**Recovered**	**Dead**
111	3213	52	1	1	3160	787
112	3213	52	1	0	3161	787
113	3213	51	0	1	3161	787
114	3213	51	0	1	3161	787
115	3213	51	0	1	3161	787
116	3213	51	0	1	3161	787
117	3213	51	0	1	3161	787
118	3213	51	0	1	3161	787
119	3213	51	0	1	3161	787
120	3213	51	0	1	3161	787
121	3213	51	0	1	3161	787
122	3213	51	0	0	3162	787

Table A.3: Run 03: Time series table of the total number of population, susceptible, exposed, infected, recovered, and dead agents from day 1, the start of execution to day 122, when the number of exposed and infected agents became 0.

Day	Population	Susceptible	Exposed	Infected	Recovered	Dead
1	4000	3995	0	5	0	0
2	4000	3995	0	5	0	0
3	4000	3995	0	5	0	0
4	4000	3995	3	5	0	0
5	4000	3995	4	5	0	0
6	4000	3995	5	5	0	0
7	4000	3995	6	5	0	0
8	4000	3995	10	4	1	0
9	4000	3994	16	3	3	0
10	4000	3994	19	1	5	0
11	4000	3993	17	2	5	0
12	4000	3991	22	4	5	0
13	4000	3991	26	4	5	0
14	4000	3991	32	4	5	0
15	4000	3990	35	5	5	0
16	4000	3989	46	6	5	0
17	4000	3988	51	6	6	0
18	4000	3987	66	7	6	0
19	4000	3982	80	12	6	0
20	4000	3982	115	11	7	0

Day	Population	Susceptible	Exposed	Infected	Recovered	Dead
21	4000	3979	150	12	9	0
22	4000	3976	188	15	9	0
23	4000	3974	266	16	10	0
24	4000	3964	346	25	11	0
25	4000	3951	506	38	11	0
26	4000	3936	739	52	12	0
27	4000	3933	1055	53	14	0
28	3999	3911	1459	72	16	1
29	3999	3873	2009	106	20	1
30	3998	3841	2590	136	21	2
31	3998	3777	3138	196	25	2
32	3995	3705	3391	260	30	5
33	3995	3572	3428	389	34	5
34	3989	3422	3305	523	44	11
35	3987	3211	3117	722	54	13
36	3986	2957	2880	958	71	14
37	3983	2705	2655	1187	91	17
38	3976	2429	2382	1431	116	24
39	3968	2205	2179	1610	153	32
40	3955	2015	1997	1738	202	45
41	3918	1873	1856	1759	286	82
42	3888	1766	1749	1746	376	112
43	3843	1654	1645	1666	523	157
44	3802	1542	1528	1572	688	198
45	3761	1430	1413	1441	890	239
46	3702	1319	1301	1283	1100	298
47	3659	1224	1203	1139	1296	341
48	3606	1142	1115	1006	1458	394
49	3570	1041	1017	937	1592	430
50	3541	965	947	863	1713	459

Day	**Population**	**Susceptible**	**Exposed**	**Infected**	**Recovered**	**Dead**
51	3514	898	878	822	1794	486
52	3496	821	800	793	1882	504
53	3477	751	728	755	1971	523
54	3462	677	653	721	2064	538
55	3438	621	586	668	2149	562
56	3419	567	545	633	2219	581
57	3400	528	506	570	2302	600
58	3389	487	467	527	2375	611
59	3380	442	423	497	2441	620
60	3370	403	383	464	2503	630
61	3358	371	348	434	2553	642
62	3344	338	305	392	2614	656
63	3328	304	286	338	2686	672
64	3322	273	245	329	2720	678
65	3314	251	224	307	2756	686
66	3307	230	195	281	2796	693
67	3306	212	184	264	2830	694
68	3302	199	173	234	2869	698
69	3297	186	160	208	2903	703
70	3294	177	149	188	2929	706
71	3289	162	136	176	2951	711
72	3281	146	119	158	2977	719
73	3273	134	100	133	3006	727
74	3267	126	93	114	3027	733
75	3263	118	86	105	3040	737
76	3259	110	83	100	3049	741
77	3259	96	69	101	3062	741
78	3254	90	58	94	3070	746
79	3252	87	53	85	3080	748
80	3250	87	51	67	3096	750

Day	Population	Susceptible	Exposed	Infected	Recovered	Dead
81	3248	82	44	61	3105	752
82	3245	79	40	53	3113	755
83	3244	73	40	50	3121	756
84	3244	72	40	43	3129	756
85	3239	68	37	37	3134	761
86	3239	66	32	28	3145	761
87	3239	63	28	27	3149	761
88	3239	61	25	26	3152	761
89	3238	61	23	23	3154	762
90	3238	56	18	26	3156	762
91	3238	55	18	22	3161	762
92	3237	54	15	18	3165	763
93	3237	52	12	19	3166	763
94	3236	52	11	16	3168	764
95	3235	52	10	13	3170	765
96	3235	52	10	12	3171	765
97	3235	50	9	11	3174	765
98	3235	48	7	11	3176	765
99	3235	48	8	9	3178	765
100	3235	46	7	9	3180	765
101	3235	45	6	9	3181	765
102	3235	44	5	8	3183	765
103	3235	44	5	8	3183	765
104	3235	43	4	9	3183	765
105	3235	43	5	9	3183	765
106	3235	43	8	9	3183	765
107	3235	40	5	8	3187	765
108	3235	40	6	7	3188	765
109	3235	40	7	7	3188	765
110	3235	40	7	5	3190	765

Day	Population	Susceptible	Exposed	Infected	Recovered	Dead
111	3234	40	8	4	3190	766
112	3234	37	5	7	3190	766
113	3234	37	6	7	3190	766
114	3234	37	6	5	3192	766
115	3234	37	4	3	3194	766
116	3234	36	3	4	3194	766
117	3234	36	3	4	3194	766
118	3234	35	2	5	3194	766
119	3234	34	1	6	3194	766
120	3233	34	1	5	3194	767
121	3233	34	2	4	3195	767
122	3233	34	2	3	3196	767
123	3233	34	2	3	3196	767
124	3232	34	3	2	3196	768
125	3232	34	3	2	3196	768
126	3232	34	2	2	3196	768
127	3232	34	2	0	3198	768
128	3232	34	2	0	3198	768
129	3232	34	2	0	3198	768
130	3232	34	2	0	3198	768
131	3232	34	1	0	3198	768
132	3232	34	1	0	3198	768
133	3232	34	0	0	3198	768

Table A.4: Run 04: Time series table of the total number of population, susceptible, exposed, infected, recovered, and dead agents from day 1, the start of execution to day 133, when the number of exposed and infected agents became 0.

Day	**Population**	**Susceptible**	**Exposed**	**Infected**	**Recovered**	**Dead**
1	4000	3995	0	5	0	0
2	4000	3995	2	5	0	0
3	4000	3995	5	5	0	0
4	4000	3995	11	5	0	0
5	4000	3995	13	5	0	0
6	4000	3995	15	5	0	0
7	4000	3995	24	5	0	0
8	3999	3995	32	4	0	1
9	3998	3995	34	2	1	2
10	3997	3993	32	3	1	3
11	3997	3989	37	6	2	3
12	3997	3987	40	8	2	3
13	3997	3984	56	11	2	3
14	3997	3983	69	12	2	3
15	3997	3980	100	15	2	3
16	3997	3979	139	16	2	3
17	3996	3974	229	20	2	4
18	3996	3973	314	20	3	4
19	3996	3969	412	23	4	4
20	3994	3958	545	30	6	6

Day	**Population**	**Susceptible**	**Exposed**	**Infected**	**Recovered**	**Dead**
21	3994	3946	712	38	10	6
22	3994	3930	996	53	11	6
23	3993	3895	1452	86	12	7
24	3992	3864	2055	115	13	8
25	3990	3826	2654	151	13	10
26	3989	3764	3165	210	15	11
27	3989	3687	3425	284	18	11
28	3988	3598	3457	368	22	12
29	3984	3466	3362	490	28	16
30	3982	3264	3164	671	47	18
31	3974	3006	2933	906	62	26
32	3968	2699	2647	1186	83	32
33	3957	2421	2384	1419	117	43
34	3950	2166	2139	1631	153	50
35	3938	1974	1951	1762	202	62
36	3923	1826	1814	1821	276	77
37	3906	1722	1709	1811	373	94
38	3871	1610	1593	1737	524	129
39	3836	1502	1491	1659	675	164
40	3779	1389	1372	1500	890	221
41	3737	1278	1264	1319	1140	263
42	3687	1169	1145	1159	1359	313
43	3639	1065	1046	1038	1536	361
44	3607	973	958	975	1659	393
45	3578	903	873	900	1775	422
46	3545	839	817	847	1859	455
47	3521	764	738	805	1952	479
48	3499	695	670	763	2041	501
49	3479	639	619	707	2133	521
50	3455	574	548	657	2224	545

Day	**Population**	**Susceptible**	**Exposed**	**Infected**	**Recovered**	**Dead**
51	3434	526	504	602	2306	566
52	3422	486	460	548	2388	578
53	3396	445	417	503	2448	604
54	3378	403	380	490	2485	622
55	3364	375	347	431	2558	636
56	3351	338	311	388	2625	649
57	3336	311	285	349	2676	664
58	3329	287	255	328	2714	671
59	3317	270	246	293	2754	683
60	3306	247	227	259	2800	694
61	3300	220	195	243	2837	700
62	3291	201	175	230	2860	709
63	3285	185	155	214	2886	715
64	3274	170	145	196	2908	726
65	3264	154	128	177	2933	736
66	3261	149	128	160	2952	739
67	3253	133	108	147	2973	747
68	3251	123	98	141	2987	749
69	3244	120	87	114	3010	756
70	3239	113	75	97	3029	761
71	3235	106	71	91	3038	765
72	3228	102	65	75	3051	772
73	3225	93	54	72	3060	775
74	3221	84	45	69	3068	779
75	3218	83	43	57	3078	782
76	3217	78	39	55	3084	783
77	3213	78	41	41	3094	787
78	3213	71	34	45	3097	787
79	3213	69	35	43	3101	787
80	3213	68	35	37	3108	787

Day	Population	Susceptible	Exposed	Infected	Recovered	Dead
81	3212	63	30	35	3114	788
82	3210	61	25	30	3119	790
83	3209	58	25	26	3125	791
84	3209	56	25	25	3128	791
85	3209	54	22	25	3130	791
86	3207	53	18	21	3133	793
87	3207	52	16	21	3134	793
88	3207	51	16	17	3139	793
89	3207	49	15	18	3140	793
90	3205	46	10	17	3142	795
91	3204	46	10	13	3145	796
92	3204	45	10	11	3148	796
93	3204	43	8	11	3150	796
94	3203	43	10	9	3151	797
95	3203	43	11	9	3151	797
96	3203	42	10	10	3151	797
97	3203	38	7	13	3152	797
98	3203	37	6	13	3153	797
99	3202	37	8	10	3155	798
100	3200	36	6	8	3156	800
101	3200	36	5	8	3156	800
102	3200	36	6	7	3157	800
103	3200	36	7	7	3157	800
104	3200	34	4	9	3157	800
105	3199	34	4	6	3159	801
106	3199	34	5	4	3161	801
107	3199	34	6	3	3162	801
108	3199	33	5	3	3163	801
109	3199	33	5	3	3163	801
110	3199	32	4	4	3163	801

Day	Population	Susceptible	Exposed	Infected	Recovered	Dead
111	3199	31	3	4	3164	801
112	3199	29	1	6	3164	801
113	3199	29	1	5	3165	801
114	3199	29	1	5	3165	801
115	3199	29	1	5	3165	801
116	3199	29	0	5	3165	801
117	3199	29	1	5	3165	801
118	3199	29	1	4	3166	801
119	3199	29	1	3	3167	801
120	3199	29	1	1	3169	801
121	3198	29	1	0	3169	802
122	3198	29	1	0	3169	802
123	3198	29	1	0	3169	802
124	3198	29	1	0	3169	802
125	3198	28	0	1	3169	802
126	3198	28	0	1	3169	802
127	3198	28	0	1	3169	802
128	3198	28	0	1	3169	802
129	3198	28	0	1	3169	802
130	3198	28	0	1	3169	802
131	3198	28	0	1	3169	802
132	3198	28	0	1	3169	802
133	3198	28	0	1	3169	802
134	3198	28	0	0	3170	802

Table A.5: Run 05: Time series table of the total number of population, susceptible, exposed, infected, recovered, and dead agents from day 1, the start of execution to day 134, when the number of exposed and infected agents became 0.

Appendix B

Figures for Scenario 01

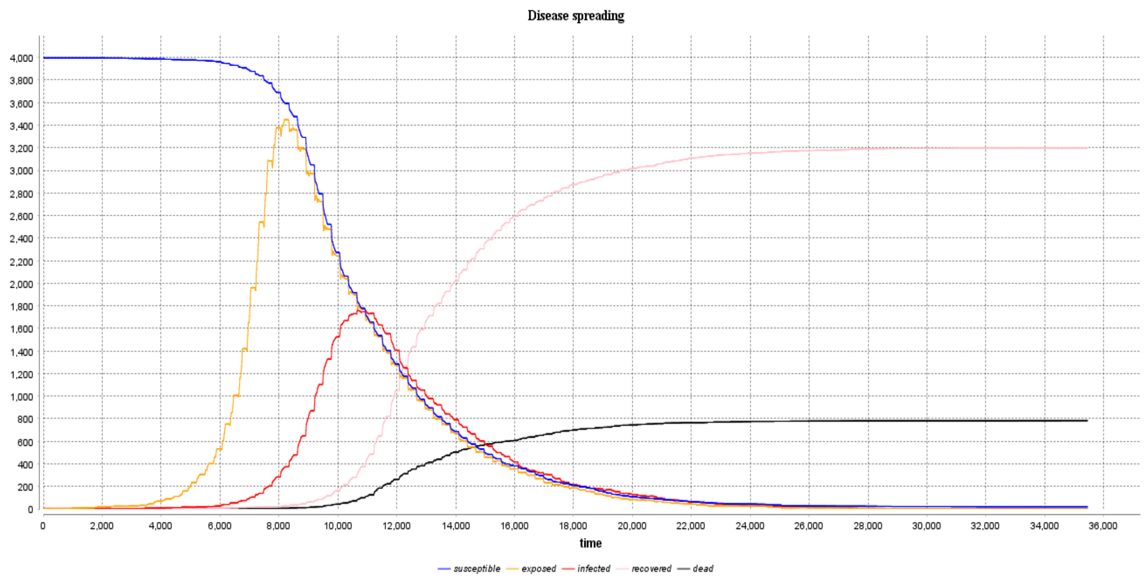

Figure B.1: Time Series chart of Scenario 01 Run 01.

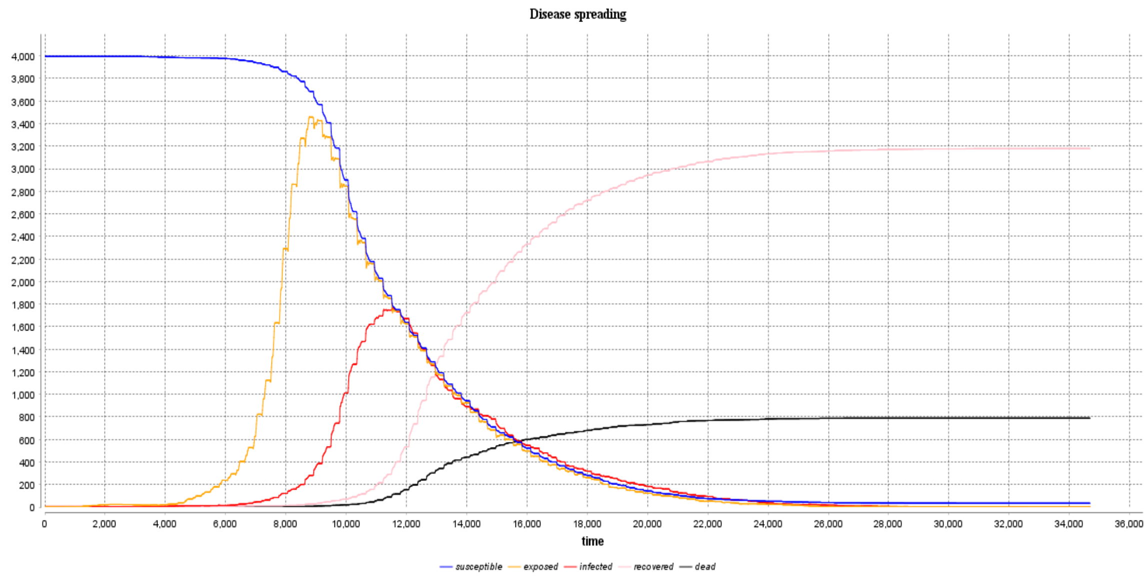

Figure B.2: Time Series chart of Scenario 01 Run 02.

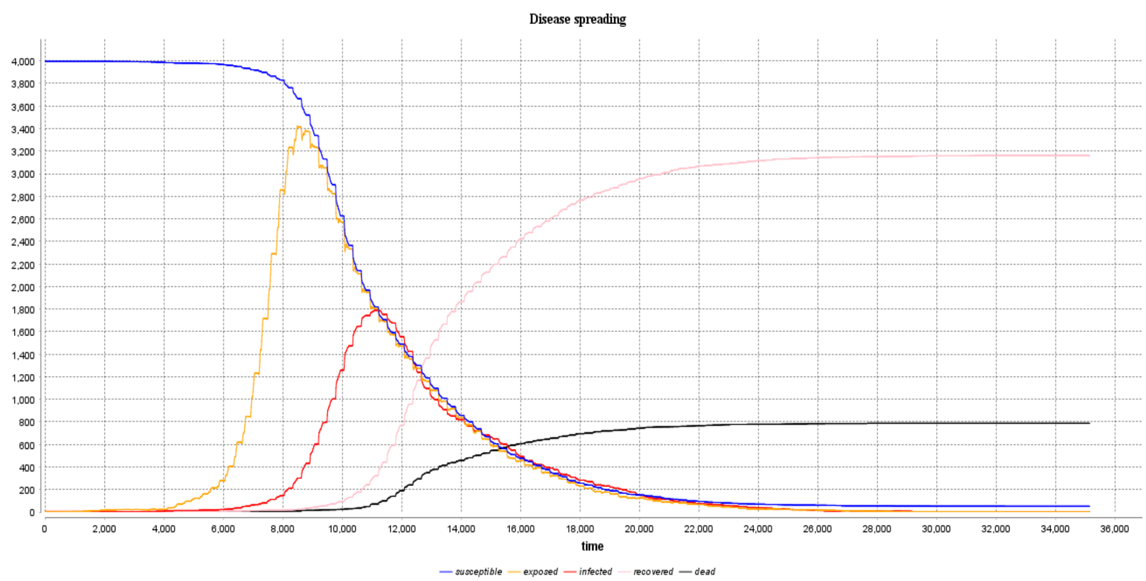

Figure B.3: Time Series chart of Scenario 01 Run 03.

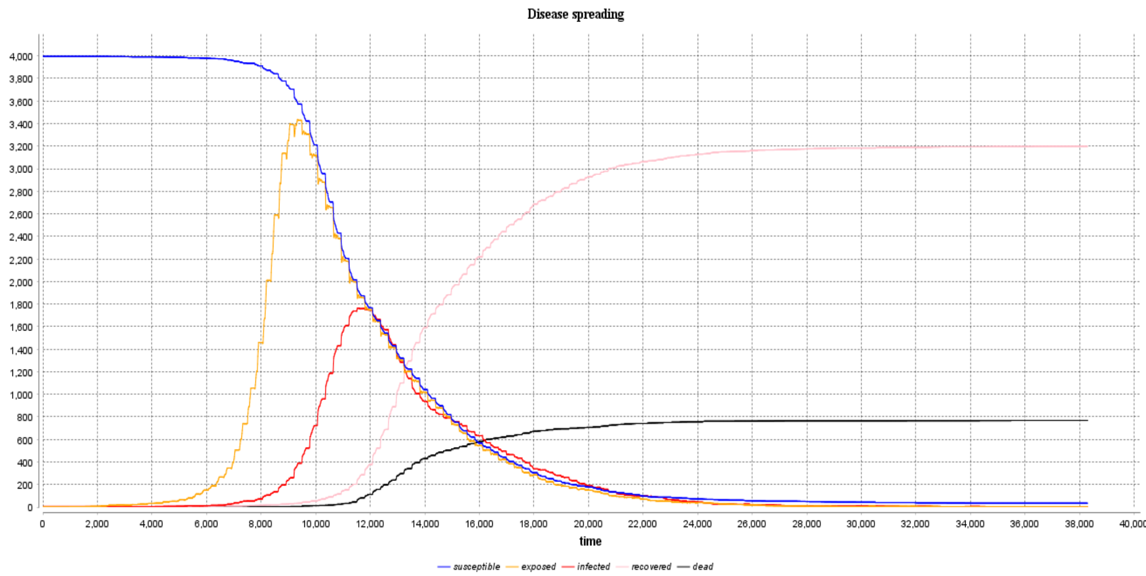

Figure B.4: Time Series chart of Scenario 01 Run 04.

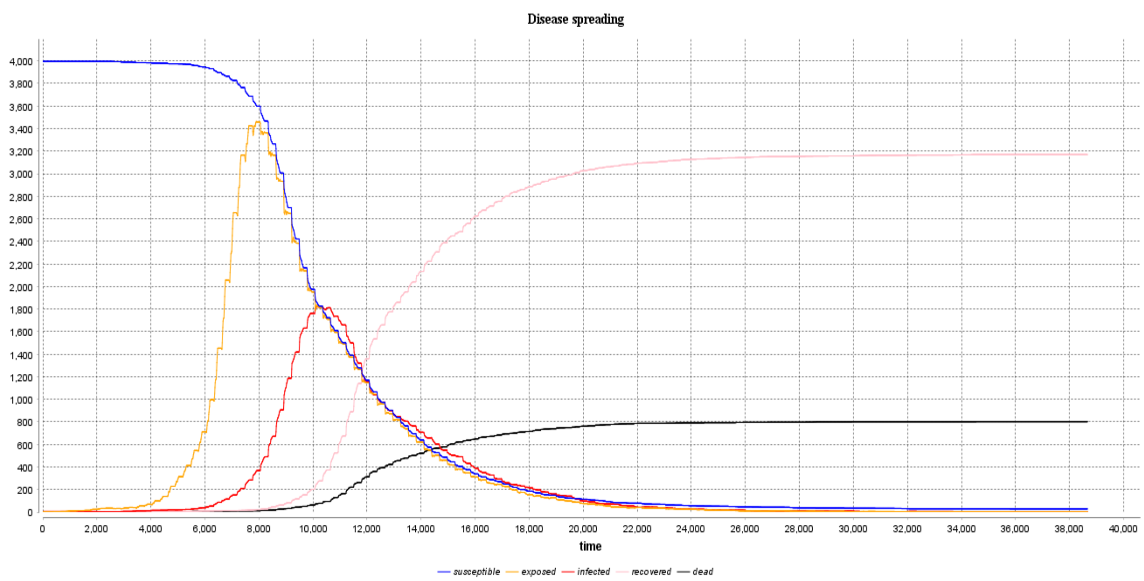

Figure B.5: Time Series chart of Scenario 01 Run 05.

Appendix C

Table for Scenario 02.1

Day	Population	Susceptible	Exposed	Infected	Recovered	Dead
1	4000	3995	0	5	0	0
2	4000	3995	0	5	0	0
3	4000	3995	1	5	0	0
4	4000	3995	2	5	0	0
5	4000	3995	5	5	0	0
6	4000	3995	7	5	0	0
7	4000	3995	32	5	0	0
8	4000	3995	35	4	1	0
9	4000	3995	35	3	2	0
10	3999	3995	35	2	2	1
11	3999	3993	33	2	4	1
12	3999	3991	30	4	4	1
13	3999	3988	32	7	4	1
14	3999	3986	34	9	4	1
15	3999	3980	33	15	4	1
16	3999	3977	35	18	4	1
17	3999	3977	35	18	4	1
18	3999	3977	35	18	4	1
19	3998	3977	34	16	5	2
20	3998	3977	35	15	6	2

Day	**Population**	**Susceptible**	**Exposed**	**Infected**	**Recovered**	**Dead**
21	3997	3974	41	15	8	3
22	3995	3972	52	14	9	5
23	3994	3970	79	13	11	6
24	3993	3967	106	13	13	7
25	3991	3965	130	12	14	9
26	3991	3961	158	16	14	9
27	3991	3957	225	20	14	9
28	3991	3950	354	27	14	9
29	3991	3943	500	33	15	9
30	3991	3935	721	39	17	9
31	3991	3914	1021	57	20	9
32	3991	3897	1383	71	23	9
33	3991	3873	1885	92	26	9
34	3990	3833	2460	130	27	10
35	3988	3793	2976	166	29	12
36	3987	3724	3305	232	31	13
37	3987	3610	3183	337	40	13
38	3986	3454	2953	486	46	14
39	3984	3274	2661	651	59	16
40	3981	3045	2377	862	74	19
41	3979	2794	2049	1098	87	21
42	3969	2520	1697	1342	107	31
43	3960	2311	1460	1510	139	40
44	3949	2126	1235	1638	185	51
45	3939	2019	1105	1659	261	61
46	3915	1957	1054	1593	365	85
47	3887	1910	1001	1475	502	113
48	3855	1855	950	1339	661	145
49	3800	1796	881	1160	844	200
50	3753	1729	814	965	1059	247

Day	**Population**	**Susceptible**	**Exposed**	**Infected**	**Recovered**	**Dead**
51	3712	1667	1521	791	1254	288
52	3677	1609	1575	646	1422	323
53	3646	1540	1515	557	1549	354
54	3631	1493	1460	504	1634	369
55	3616	1439	1415	500	1677	384
56	3603	1382	1342	513	1708	397
57	3593	1241	1188	590	1762	407
58	3583	1103	1056	665	1815	417
59	3575	980	931	724	1871	425
60	3564	841	813	796	1927	436
61	3554	740	723	840	1974	446
62	3542	692	677	833	2017	458
63	3533	651	636	831	2051	467
64	3517	611	594	789	2117	483
65	3499	565	553	742	2192	501
66	3470	526	511	662	2282	530
67	3444	478	428	585	2381	556
68	3416	423	350	512	2481	584
69	3399	378	286	435	2586	601
70	3385	341	232	390	2654	615
71	3376	321	190	359	2696	624
72	3370	300	149	348	2722	630
73	3355	285	121	308	2762	645
74	3345	269	93	277	2799	655
75	3337	256	71	244	2837	663
76	3326	238	53	219	2869	674
77	3317	234	49	179	2904	683
78	3308	231	44	136	2941	692
79	3304	227	36	110	2967	696
80	3301	226	35	92	2983	699

Day	Population	Susceptible	Exposed	Infected	Recovered	Dead
81	3298	223	34	70	3005	702
82	3296	219	33	63	3014	704
83	3291	215	43	51	3025	709
84	3291	212	54	38	3041	709
85	3290	209	59	30	3051	710
86	3287	209	64	23	3055	713
87	3286	207	68	21	3058	714
88	3286	206	77	19	3061	714
89	3286	201	76	24	3061	714
90	3286	198	75	25	3063	714
91	3284	192	72	25	3067	716
92	3284	185	70	29	3070	716
93	3282	177	62	32	3073	718
94	3282	171	62	38	3073	718
95	3282	166	72	43	3073	718
96	3282	161	74	45	3076	718
97	3281	156	66	45	3080	719
98	3281	151	57	48	3082	719
99	3280	147	53	49	3084	720
100	3278	144	50	44	3090	722
101	3278	140	39	42	3096	722
102	3277	134	25	41	3102	723
103	3277	132	21	37	3108	723
104	3277	130	16	35	3112	723
105	3275	124	6	38	3113	725
106	3272	122	3	31	3119	728
107	3271	122	3	28	3121	729
108	3271	122	3	26	3123	729
109	3271	121	2	18	3132	729
110	3270	121	2	16	3133	730

Day	Population	Susceptible	Exposed	Infected	Recovered	Dead
111	3270	121	7	12	3137	730
112	3270	121	12	11	3138	730
113	3270	121	12	7	3142	730
114	3270	120	14	4	3146	730
115	3270	120	14	3	3147	730
116	3269	120	14	2	3147	731
117	3269	119	13	3	3147	731
118	3269	119	10	2	3148	731
119	3269	118	8	3	3148	731
120	3269	117	7	4	3148	731
121	3269	116	5	5	3148	731
122	3269	116	5	4	3149	731
123	3269	115	4	5	3149	731
124	3269	115	5	5	3149	731
125	3269	115	5	4	3150	731
126	3269	114	4	5	3150	731
127	3269	114	4	4	3151	731
128	3269	113	3	5	3151	731
129	3268	113	3	3	3152	732
130	3268	113	2	3	3152	732
131	3268	113	2	2	3153	732
132	3268	113	1	2	3153	732
133	3268	113	1	2	3153	732
134	3268	112	0	3	3153	732
135	3267	112	0	2	3153	733
136	3267	112	0	2	3153	733
137	3267	112	0	2	3153	733
138	3266	112	0	1	3153	734
139	3266	112	0	1	3153	734
140	3266	112	0	1	3153	734

Day	**Population**	**Susceptible**	**Exposed**	**Infected**	**Recovered**	**Dead**
141	3266	112	0	1	3153	734
142	3266	112	0	1	3153	734
143	3266	112	0	0	3154	734

Table C.1: Run 01: Time series table of the total number of population, susceptible, exposed, infected, recovered, and dead agents from day 1, the start of execution to day 143, when the number of exposed and infected agents became 0.

Day	**Population**	**Susceptible**	**Exposed**	**Infected**	**Recovered**	**Dead**
1	4000	3995	0	5	0	0
2	4000	3995	2	5	0	0
3	4000	3995	2	5	0	0
4	4000	3995	2	5	0	0
5	4000	3995	9	5	0	0
6	4000	3995	11	5	0	0
7	4000	3995	24	5	0	0
8	4000	3995	26	5	0	0
9	4000	3995	26	2	3	0
10	4000	3993	25	3	4	0
11	3999	3992	29	3	4	1
12	3999	3991	30	4	4	1
13	3999	3986	32	9	4	1
14	3999	3983	41	12	4	1
15	3999	3983	41	12	4	1
16	3999	3981	42	14	4	1
17	3999	3977	45	18	4	1
18	3999	3976	49	19	4	1
19	3999	3975	53	19	5	1
20	3999	3972	53	18	9	1

Day	**Population**	**Susceptible**	**Exposed**	**Infected**	**Recovered**	**Dead**
21	3998	3971	76	17	10	2
22	3998	3965	105	20	13	2
23	3998	3963	150	22	13	2
24	3998	3959	224	22	17	2
25	3998	3955	315	25	18	2
26	3998	3949	440	30	19	2
27	3998	3940	616	36	22	2
28	3998	3931	867	44	23	2
29	3997	3922	1138	51	24	3
30	3995	3893	1485	75	27	5
31	3993	3858	2030	104	31	7
32	3992	3821	2566	139	32	8
33	3992	3752	3048	204	36	8
34	3990	3661	3330	286	43	10
35	3990	3559	3386	381	50	10
36	3989	3422	3314	512	55	11
37	3987	3243	3053	682	62	13
38	3984	3007	2678	894	83	16
39	3980	2744	2314	1136	100	20
40	3969	2476	1937	1359	134	31
41	3959	2233	1608	1545	181	41
42	3944	2016	1364	1685	243	56
43	3930	1859	1167	1758	313	70
44	3917	1761	1066	1752	404	83
45	3886	1681	982	1663	542	114
46	3848	1607	889	1533	708	152
47	3812	1570	845	1342	900	188
48	3763	1523	782	1133	1107	237
49	3721	1462	717	931	1328	279
50	3678	1408	650	757	1513	322

Day	Population	Susceptible	Exposed	Infected	Recovered	Dead
51	3632	1355	1133	624	1653	368
52	3610	1304	1244	540	1766	390
53	3592	1260	1230	488	1844	408
54	3577	1221	1195	440	1916	423
55	3565	1179	1152	424	1962	435
56	3558	1126	1092	420	2012	442
57	3548	1022	958	468	2058	452
58	3536	928	861	504	2104	464
59	3525	825	768	562	2138	475
60	3512	731	688	603	2178	488
61	3501	638	600	649	2214	499
62	3492	599	590	645	2248	508
63	3473	558	543	641	2274	527
64	3463	534	508	612	2317	537
65	3441	501	475	580	2360	559
66	3417	454	433	544	2419	583
67	3393	399	353	496	2498	607
68	3368	354	281	439	2575	632
69	3343	328	233	371	2644	657
70	3335	307	201	318	2710	665
71	3323	283	157	300	2740	677
72	3316	262	131	287	2767	684
73	3311	245	107	281	2785	689
74	3297	227	77	256	2814	703
75	3293	215	59	222	2856	707
76	3279	205	46	174	2900	721
77	3273	197	37	151	2925	727
78	3268	193	32	125	2950	732
79	3265	190	27	103	2972	735
80	3260	186	21	87	2987	740

Day	Population	Susceptible	Exposed	Infected	Recovered	Dead
81	3257	182	22	73	3002	743
82	3252	181	26	57	3014	748
83	3250	180	34	47	3023	750
84	3245	180	40	34	3031	755
85	3242	178	45	27	3037	758
86	3240	177	48	19	3044	760
87	3239	173	44	19	3047	761
88	3238	170	52	20	3048	762
89	3237	168	52	16	3053	763
90	3236	164	56	17	3055	764
91	3236	161	59	19	3056	764
92	3236	156	57	23	3057	764
93	3236	151	55	28	3057	764
94	3236	149	55	29	3058	764
95	3235	148	54	26	3061	765
96	3235	144	53	28	3063	765
97	3234	138	45	31	3065	766
98	3233	133	35	34	3066	767
99	3230	129	27	31	3070	770
100	3229	121	18	34	3074	771
101	3229	118	15	36	3075	771
102	3228	116	11	34	3078	772
103	3225	114	7	33	3078	775
104	3224	112	5	33	3079	776
105	3223	112	3	28	3083	777
106	3222	112	3	24	3086	778
107	3219	111	2	18	3090	781
108	3217	111	2	13	3093	783
109	3216	111	2	8	3097	784
110	3215	111	2	6	3098	785

Day	Population	Susceptible	Exposed	Infected	Recovered	Dead
111	3215	111	4	5	3099	785
112	3215	111	3	3	3101	785
113	3214	111	3	1	3102	786
114	3214	110	2	2	3102	786
115	3214	110	2	2	3102	786
116	3214	110	2	1	3103	786
117	3214	109	0	2	3103	786
118	3214	109	1	2	3103	786
119	3214	109	3	2	3103	786
120	3214	109	3	2	3103	786
121	3214	109	3	2	3103	786
122	3214	109	3	2	3103	786
123	3214	109	3	1	3104	786
124	3214	109	3	0	3105	786
125	3214	109	3	0	3105	786
126	3214	108	2	1	3105	786
127	3214	108	2	1	3105	786
128	3214	108	1	1	3105	786
129	3214	108	1	1	3105	786
130	3214	108	1	1	3105	786
131	3214	108	1	1	3105	786
132	3214	108	1	1	3105	786
133	3214	108	0	1	3105	786
134	3214	108	0	1	3105	786
135	3214	108	0	0	3106	786

Table C.2: Run 02: Time series table of the total number of population, susceptible, exposed, infected, recovered, and dead agents from day 1, the start of execution to day 135, when the number of exposed and infected agents became 0.

Day	**Population**	**Susceptible**	**Exposed**	**Infected**	**Recovered**	**Dead**
1	4000	3995	0	5	0	0
2	4000	3995	0	5	0	0
3	4000	3995	0	5	0	0
4	4000	3995	4	5	0	0
5	4000	3995	7	5	0	0
6	4000	3995	7	5	0	0
7	4000	3995	15	5	0	0
8	3999	3995	17	3	1	1
9	3999	3995	17	3	1	1
10	3998	3995	17	0	3	2
11	3998	3994	16	1	3	2
12	3998	3993	18	2	3	2
13	3998	3991	14	4	3	2
14	3998	3989	14	6	3	2
15	3998	3987	13	8	3	2
16	3998	3985	11	10	3	2
17	3998	3984	9	11	3	2
18	3998	3982	10	12	4	2
19	3998	3981	9	13	4	2
20	3998	3981	9	13	4	2

Day	**Population**	**Susceptible**	**Exposed**	**Infected**	**Recovered**	**Dead**
21	3998	3981	18	12	5	2
22	3998	3978	29	14	6	2
23	3998	3978	43	10	10	2
24	3998	3977	63	10	11	2
25	3998	3977	89	7	14	2
26	3996	3977	111	4	15	4
27	3996	3972	125	9	15	4
28	3996	3964	163	17	15	4
29	3996	3958	244	22	16	4
30	3996	3951	363	28	17	4
31	3996	3942	529	36	18	4
32	3996	3930	781	48	18	4
33	3996	3925	1100	53	18	4
34	3996	3909	1489	68	19	4
35	3995	3878	1994	94	23	5
36	3993	3840	2487	128	25	7
37	3992	3793	2499	167	32	8
38	3990	3709	2417	241	40	10
39	3988	3599	2285	346	43	12
40	3988	3441	2144	496	51	12
41	3986	3246	1953	683	57	14
42	3983	3021	1710	892	70	17
43	3981	2838	1504	1055	88	19
44	3973	2660	1315	1203	110	27
45	3966	2528	1193	1300	138	34
46	3952	2456	1134	1292	204	48
47	3934	2390	1072	1267	277	66
48	3912	2333	1020	1189	390	88
49	3871	2263	958	1094	514	129
50	3831	2208	887	958	665	169

Day	**Population**	**Susceptible**	**Exposed**	**Infected**	**Recovered**	**Dead**
51	3796	2133	2004	827	836	204
52	3756	2080	2048	694	982	244
53	3736	2021	1993	609	1106	264
54	3715	1959	1934	556	1200	285
55	3699	1898	1870	541	1260	301
56	3685	1811	1771	555	1319	315
57	3676	1642	1561	675	1359	324
58	3658	1472	1412	779	1407	342
59	3648	1311	1255	875	1462	352
60	3631	1154	1094	958	1519	369
61	3621	1041	1019	1015	1565	379
62	3612	993	986	1007	1612	388
63	3599	946	939	982	1671	401
64	3575	889	877	958	1728	425
65	3554	822	804	913	1819	446
66	3527	754	734	820	1953	473
67	3494	683	630	739	2072	506
68	3459	618	523	637	2204	541
69	3423	555	427	564	2304	577
70	3407	502	352	538	2367	593
71	3394	464	294	518	2412	606
72	3383	435	249	488	2460	617
73	3373	407	198	464	2502	627
74	3360	377	153	421	2562	640
75	3355	355	124	381	2619	645
76	3338	340	105	319	2679	662
77	3316	328	91	268	2720	684
78	3308	323	81	216	2769	692
79	3300	316	70	178	2806	700
80	3291	312	64	144	2835	709

Day	**Population**	**Susceptible**	**Exposed**	**Infected**	**Recovered**	**Dead**
81	3284	312	79	110	2862	716
82	3279	300	98	101	2878	721
83	3273	293	116	76	2904	727
84	3268	288	139	62	2918	732
85	3264	284	157	52	2928	736
86	3263	283	171	44	2936	737
87	3262	274	173	44	2944	738
88	3262	264	171	51	2947	738
89	3262	255	167	56	2951	738
90	3262	236	159	73	2953	738
91	3262	225	144	73	2964	738
92	3260	206	140	86	2968	740
93	3260	199	137	88	2973	740
94	3257	187	133	95	2975	743
95	3257	177	126	102	2978	743
96	3254	170	113	95	2989	746
97	3251	160	99	97	2994	749
98	3248	152	84	98	2998	752
99	3245	138	64	100	3007	755
100	3240	125	46	90	3025	760
101	3240	120	35	83	3037	760
102	3238	116	22	78	3044	762
103	3236	112	16	75	3049	764
104	3233	109	8	68	3056	767
105	3227	107	3	55	3065	773
106	3225	107	3	44	3074	775
107	3223	107	3	35	3081	777
108	3223	107	3	27	3089	777
109	3221	106	2	21	3094	779
110	3219	106	2	12	3101	781

Day	**Population**	**Susceptible**	**Exposed**	**Infected**	**Recovered**	**Dead**
111	3219	105	3	10	3104	781
112	3219	105	7	9	3105	781
113	3216	105	7	3	3108	784
114	3216	105	7	2	3109	784
115	3216	105	7	2	3109	784
116	3216	105	9	2	3109	784
117	3216	105	9	2	3109	784
118	3216	105	8	1	3110	784
119	3216	104	6	2	3110	784
120	3216	102	3	3	3111	784
121	3216	102	3	3	3111	784
122	3216	102	3	3	3111	784
123	3216	102	5	3	3111	784
124	3216	102	5	3	3111	784
125	3216	102	5	3	3111	784
126	3216	101	5	4	3111	784
127	3216	101	5	4	3111	784
128	3216	101	5	4	3111	784
129	3216	100	1	4	3112	784
130	3215	100	1	2	3113	785
131	3215	100	1	2	3113	785
132	3215	99	0	3	3113	785
133	3215	99	0	3	3113	785
134	3215	99	0	2	3114	785
135	3215	99	0	2	3114	785
136	3215	99	0	2	3114	785
137	3215	99	0	2	3114	785
138	3215	99	0	2	3114	785
139	3215	99	0	1	3115	785

Day	Population	Susceptible	Exposed	Infected	Recovered	Dead
140	3215	99	0	0	3116	785

Table C.3: Run 03: Time series table of the total number of population, susceptible, exposed, infected, recovered, and dead agents from day 1, the start of execution to day 140, when the number of exposed and infected agents became 0.

Day	**Population**	**Susceptible**	**Exposed**	**Infected**	**Recovered**	**Dead**
1	4000	3995	1	5	0	0
2	4000	3995	3	5	0	0
3	4000	3995	5	5	0	0
4	4000	3995	6	5	0	0
5	4000	3995	7	5	0	0
6	4000	3995	11	5	0	0
7	4000	3995	14	5	0	0
8	4000	3995	14	3	2	0
9	4000	3994	12	3	3	0
10	4000	3994	12	2	4	0
11	4000	3993	10	2	5	0
12	4000	3992	9	3	5	0
13	4000	3988	21	7	5	0
14	4000	3988	25	7	5	0
15	4000	3988	25	7	5	0
16	4000	3986	29	9	5	0
17	4000	3984	27	10	6	0
18	4000	3984	28	10	6	0
19	4000	3983	31	11	6	0
20	3999	3982	31	10	7	1

Day	Population	Susceptible	Exposed	Infected	Recovered	Dead
21	3999	3979	36	10	10	1
22	3999	3974	41	14	11	1
23	3999	3973	63	15	11	1
24	3998	3971	87	16	11	2
25	3997	3970	117	15	12	3
26	3996	3967	161	17	12	4
27	3995	3965	216	18	12	5
28	3995	3961	290	22	12	5
29	3995	3957	397	24	14	5
30	3995	3944	547	34	17	5
31	3994	3933	781	42	19	6
32	3994	3919	1121	53	22	6
33	3993	3892	1592	79	22	7
34	3991	3866	2062	102	23	9
35	3991	3827	2620	137	27	9
36	3991	3773	3115	190	28	9
37	3988	3693	3055	263	32	12
38	3986	3576	2903	376	34	14
39	3984	3438	2695	506	40	16
40	3980	3248	2428	673	59	20
41	3975	2983	2103	926	66	25
42	3972	2727	1771	1156	89	28
43	3967	2500	1511	1356	111	33
44	3953	2317	1290	1484	152	47
45	3938	2169	1141	1566	203	62
46	3925	2091	1055	1546	288	75
47	3893	2046	1016	1460	387	107
48	3860	1992	965	1338	530	140
49	3815	1939	912	1178	698	185
50	3769	1866	839	1021	882	231

Day	Population	Susceptible	Exposed	Infected	Recovered	Dead
51	3725	1810	1676	830	1085	275
52	3685	1739	1704	687	1259	315
53	3651	1676	1643	593	1382	349
54	3626	1611	1572	533	1482	374
55	3615	1549	1520	523	1543	385
56	3606	1476	1441	553	1577	394
57	3594	1328	1268	655	1611	406
58	3578	1166	1129	738	1674	422
59	3565	1059	1026	793	1713	435
60	3548	918	881	862	1768	452
61	3538	814	792	897	1827	462
62	3524	766	746	883	1875	476
63	3511	720	708	867	1924	489
64	3490	674	661	842	1974	510
65	3472	621	601	793	2058	528
66	3440	561	544	706	2173	560
67	3415	511	458	622	2282	585
68	3390	468	390	535	2387	610
69	3369	427	319	464	2478	631
70	3351	386	247	419	2546	649
71	3342	365	209	385	2592	658
72	3334	347	164	355	2632	666
73	3323	328	132	338	2657	677
74	3311	303	101	302	2706	689
75	3304	291	83	260	2753	696
76	3298	279	68	211	2808	702
77	3292	274	58	177	2841	708
78	3285	267	52	153	2865	715
79	3277	263	47	117	2897	723
80	3275	261	42	97	2917	725

Day	**Population**	**Susceptible**	**Exposed**	**Infected**	**Recovered**	**Dead**
81	3271	256	36	83	2932	729
82	3265	254	47	66	2945	735
83	3263	251	56	52	2960	737
84	3257	246	65	41	2970	743
85	3255	243	75	34	2978	745
86	3252	243	90	27	2982	748
87	3251	242	100	26	2983	749
88	3250	238	100	24	2988	750
89	3250	233	95	27	2990	750
90	3250	228	95	27	2995	750
91	3250	226	93	26	2998	750
92	3249	217	86	34	2998	751
93	3246	208	89	37	3001	754
94	3245	201	88	41	3003	755
95	3245	197	93	45	3003	755
96	3245	189	91	52	3004	755
97	3245	186	89	54	3005	755
98	3242	181	79	52	3009	758
99	3239	176	69	52	3011	761
100	3238	168	55	56	3014	762
101	3235	161	43	57	3017	765
102	3234	153	26	52	3029	766
103	3233	147	16	53	3033	767
104	3232	142	8	51	3039	768
105	3232	141	7	48	3043	768
106	3231	138	3	47	3046	769
107	3228	138	3	40	3050	772
108	3228	138	3	35	3055	772
109	3228	138	3	30	3060	772
110	3224	138	2	21	3065	776

Day	Population	Susceptible	Exposed	Infected	Recovered	Dead
111	3223	138	9	16	3069	777
112	3223	138	11	8	3077	777
113	3222	138	13	3	3081	778
114	3222	138	13	1	3083	778
115	3221	138	12	0	3083	779
116	3221	137	11	1	3083	779
117	3221	136	10	2	3083	779
118	3221	135	9	3	3083	779
119	3221	134	7	4	3083	779
120	3221	130	5	8	3083	779
121	3221	130	5	8	3083	779
122	3221	129	5	9	3083	779
123	3221	129	8	9	3083	779
124	3221	128	9	9	3084	779
125	3221	127	9	10	3084	779
126	3221	127	12	9	3085	779
127	3220	127	12	7	3086	780
128	3220	127	12	5	3088	780
129	3219	127	12	4	3088	781
130	3219	127	11	2	3090	781
131	3219	126	6	3	3090	781
132	3219	126	5	3	3090	781
133	3218	124	2	4	3090	782
134	3218	124	2	3	3091	782
135	3218	124	2	3	3091	782
136	3218	124	1	3	3091	782
137	3218	124	0	3	3091	782
138	3218	124	0	3	3091	782
139	3218	124	0	2	3092	782
140	3218	124	0	2	3092	782

Day	Population	Susceptible	Exposed	Infected	Recovered	Dead
141	3218	124	0	1	3093	782
142	3218	124	0	0	3094	782

Table C.4: Run 04: Time series table of the total number of population, susceptible, exposed, infected, recovered, and dead agents from day 1, the start of execution to day 142, when the number of exposed and infected agents became 0.

Day	**Population**	**Susceptible**	**Exposed**	**Infected**	**Recovered**	**Dead**
1	4000	3995	0	5	0	0
2	4000	3995	2	5	0	0
3	4000	3995	3	5	0	0
4	4000	3995	8	5	0	0
5	4000	3995	12	5	0	0
6	4000	3995	15	5	0	0
7	4000	3995	30	5	0	0
8	4000	3995	31	5	0	0
9	4000	3993	34	5	2	0
10	3999	3992	35	5	2	1
11	3998	3990	47	5	3	2
12	3998	3989	46	6	3	2
13	3998	3986	57	9	3	2
14	3998	3982	72	13	3	2
15	3998	3977	73	18	3	2
16	3998	3972	70	23	3	2
17	3998	3969	69	26	3	2
18	3998	3968	67	25	5	2
19	3997	3965	68	27	5	3
20	3997	3961	69	31	5	3

Day	**Population**	**Susceptible**	**Exposed**	**Infected**	**Recovered**	**Dead**
21	3996	3957	110	31	8	4
22	3996	3952	179	31	13	4
23	3996	3945	282	37	14	4
24	3996	3940	419	35	21	4
25	3996	3936	643	37	23	4
26	3996	3934	827	35	27	4
27	3995	3928	1030	37	30	5
28	3995	3914	1284	50	31	5
29	3992	3877	1624	81	34	8
30	3992	3833	2206	123	36	8
31	3991	3761	2783	191	39	9
32	3991	3675	3229	272	44	9
33	3990	3597	3385	343	50	10
34	3989	3469	3372	466	54	11
35	3989	3347	3249	585	57	11
36	3986	3158	3081	764	64	14
37	3981	2926	2747	971	84	19
38	3968	2619	2302	1228	121	32
39	3951	2372	1956	1419	160	49
40	3937	2144	1623	1579	214	63
41	3924	1934	1370	1705	285	76
42	3906	1791	1189	1744	371	94
43	3882	1703	1093	1720	459	118
44	3851	1599	968	1676	576	149
45	3817	1539	897	1528	750	183
46	3769	1477	827	1332	960	231
47	3727	1415	749	1149	1163	273
48	3678	1369	700	935	1374	322
49	3630	1312	632	766	1552	370
50	3599	1259	564	643	1697	401

Day	Population	Susceptible	Exposed	Infected	Recovered	Dead
51	3576	1206	973	560	1810	424
52	3549	1160	1099	506	1883	451
53	3537	1117	1082	470	1950	463
54	3527	1083	1053	441	2003	473
55	3510	1037	1005	424	2049	490
56	3498	1001	968	405	2092	502
57	3483	935	884	412	2136	517
58	3470	832	776	456	2182	530
59	3464	735	689	506	2223	536
60	3454	650	609	542	2262	546
61	3444	568	532	582	2294	556
62	3433	522	504	589	2322	567
63	3428	497	484	568	2363	572
64	3422	461	444	563	2398	578
65	3412	430	409	545	2437	588
66	3397	400	380	498	2499	603
67	3374	352	308	449	2573	626
68	3353	321	253	380	2652	647
69	3337	283	198	343	2711	663
70	3327	261	163	308	2758	673
71	3316	241	130	277	2798	684
72	3313	218	97	268	2827	687
73	3310	201	67	253	2856	690
74	3304	190	50	227	2887	696
75	3292	182	36	194	2916	708
76	3285	178	28	157	2950	715
77	3282	174	21	128	2980	718
78	3281	172	18	112	2997	719
79	3276	171	17	87	3018	724
80	3272	169	13	67	3036	728

Day	Population	Susceptible	Exposed	Infected	Recovered	Dead
81	3266	168	17	46	3052	734
82	3265	165	16	37	3063	735
83	3261	163	13	26	3072	739
84	3258	162	16	16	3080	742
85	3256	162	19	13	3081	744
86	3255	162	25	12	3081	745
87	3253	161	24	11	3081	747
88	3252	159	22	11	3082	748
89	3252	157	19	12	3083	748
90	3251	156	21	10	3085	749
91	3250	155	21	9	3086	750
92	3250	152	20	11	3087	750
93	3250	152	27	10	3088	750
94	3250	151	28	11	3088	750
95	3249	150	29	10	3089	751
96	3249	150	30	9	3090	751
97	3248	149	31	9	3090	752
98	3248	148	26	9	3091	752
99	3248	146	24	10	3092	752
100	3247	144	18	9	3094	753
101	3247	142	14	10	3095	753
102	3247	137	9	14	3096	753
103	3247	136	7	15	3096	753
104	3247	134	7	16	3097	753
105	3247	133	5	16	3098	753
106	3247	133	5	14	3100	753
107	3247	133	5	13	3101	753
108	3247	133	5	12	3102	753
109	3247	133	5	11	3103	753
110	3246	132	4	8	3106	754

Day	**Population**	**Susceptible**	**Exposed**	**Infected**	**Recovered**	**Dead**
111	3246	132	9	6	3108	754
112	3246	130	7	7	3109	754
113	3245	130	8	4	3111	755
114	3244	130	8	3	3111	756
115	3244	130	9	3	3111	756
116	3244	130	9	3	3111	756
117	3244	128	6	5	3111	756
118	3244	127	5	5	3112	756
119	3244	127	6	5	3112	756
120	3244	125	7	5	3114	756
121	3244	125	5	5	3114	756
122	3244	125	7	5	3114	756
123	3244	125	8	5	3114	756
124	3244	125	8	5	3114	756
125	3244	124	10	5	3115	756
126	3244	124	12	3	3117	756
127	3244	124	12	1	3119	756
128	3244	123	9	2	3119	756
129	3244	121	7	4	3119	756
130	3244	120	6	5	3119	756
131	3244	119	4	6	3119	756
132	3244	119	3	6	3119	756
133	3244	118	0	7	3119	756
134	3244	118	0	7	3119	756
135	3243	118	0	6	3119	757
136	3242	118	0	4	3120	758
137	3242	118	0	4	3120	758
138	3242	118	0	3	3121	758
139	3241	118	0	1	3122	759

Day	Population	Susceptible	Exposed	Infected	Recovered	Dead
140	3241	118	0	0	3123	759

Table C.5: Run 05: Time series table of the total number of population, susceptible, exposed, infected, recovered, and dead agents from day 1, the start of execution to day 140, when the number of exposed and infected agents became 0.

Appendix D

Figures for Scenario 02.1

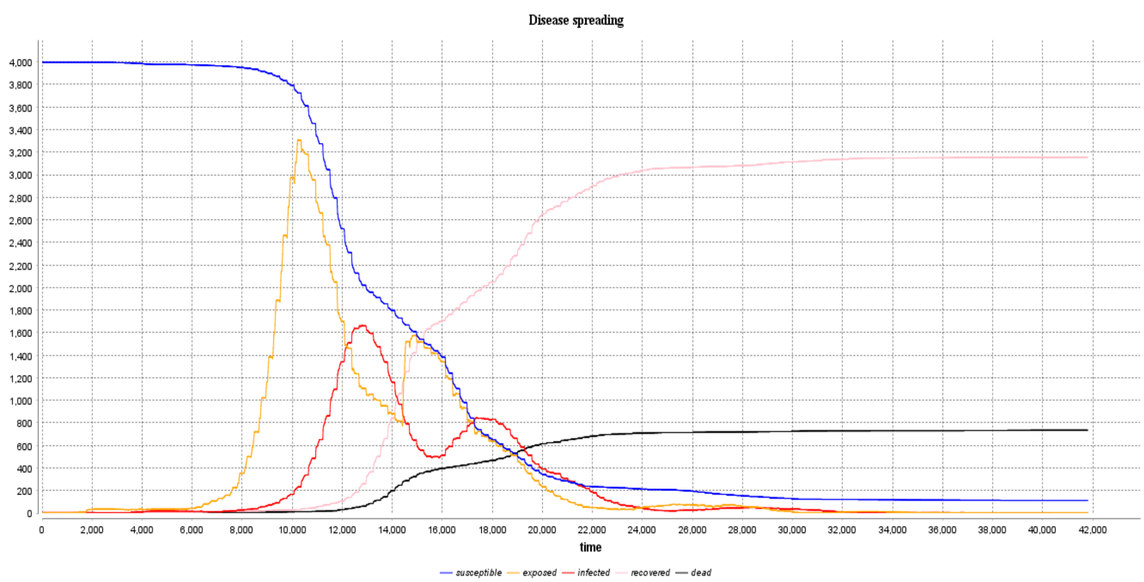

Figure D.1: Time Series chart of Scenario 02.1 Run 01.

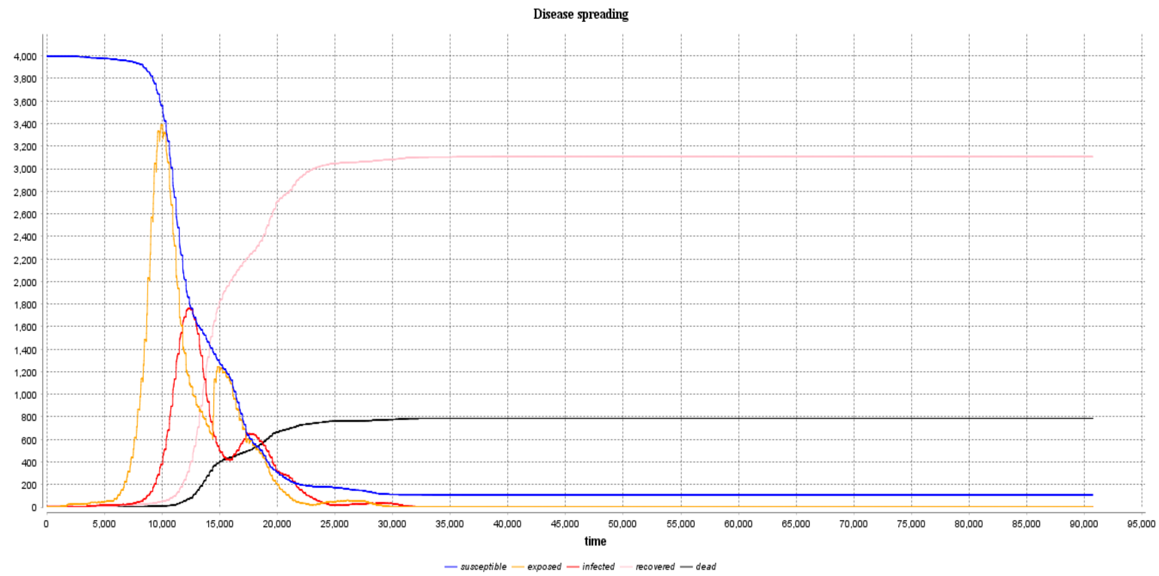

Figure D.2: Time Series chart of Scenario 02.1 Run 02.

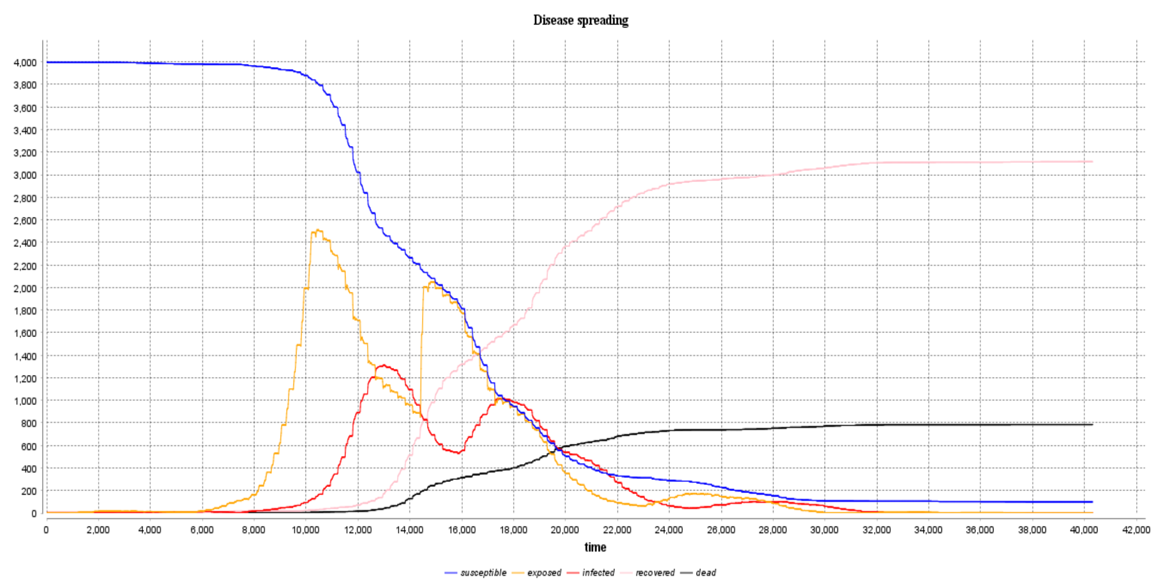

Figure D.3: Time Series chart of Scenario 02.1 Run 03.

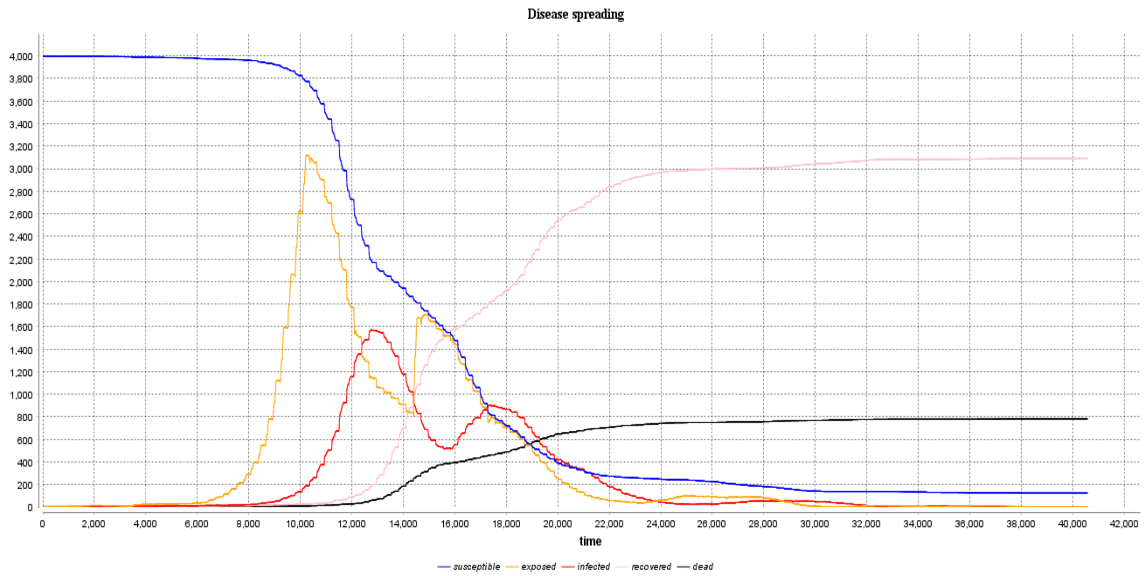

Figure D.4: Time Series chart of Scenario 02.1 Run 04.

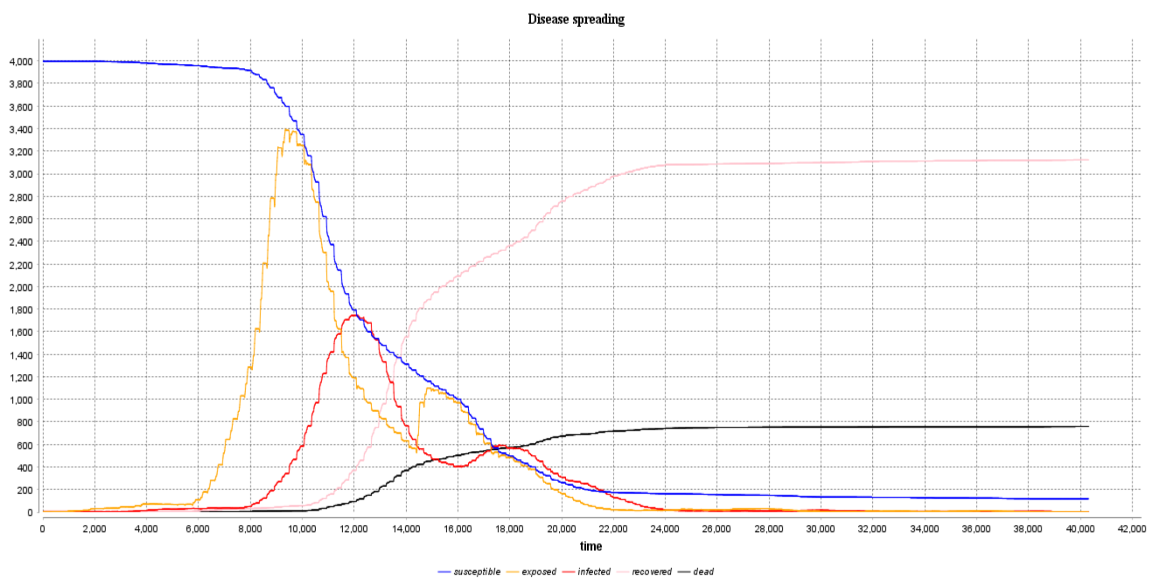

Figure D.5: Time Series chart of Scenario 02.1 Run 05.

Appendix E

Table for Scenario 02.2

Day	**Population**	**Susceptible**	**Exposed**	**Infected**	**Recovered**	**Dead**
1	4000	3995	0	5	0	0
2	4000	3995	1	5	0	0
3	4000	3995	4	5	0	0
4	4000	3995	5	5	0	0
5	4000	3995	7	5	0	0
6	4000	3995	10	5	0	0
7	4000	3995	12	5	0	0
8	4000	3995	17	5	0	0
9	3999	3994	18	3	2	1
10	3999	3993	18	2	4	1
11	3999	3993	22	2	4	1
12	3999	3993	24	2	4	1
13	3999	3990	22	5	4	1
14	3999	3989	34	6	4	1
15	3999	3988	35	7	4	1
16	3998	3988	35	6	4	2
17	3998	3988	34	6	4	2
18	3998	3985	31	9	4	2
19	3998	3982	40	11	5	2
20	3998	3981	42	12	5	2

Day	**Population**	**Susceptible**	**Exposed**	**Infected**	**Recovered**	**Dead**
21	3998	3980	41	13	5	2
22	3998	3976	44	16	6	2
23	3997	3975	45	14	8	3
24	3996	3972	42	16	8	4
25	3996	3969	47	19	8	4
26	3996	3966	45	20	10	4
27	3994	3964	47	18	12	6
28	3994	3959	72	22	13	6
29	3994	3957	113	21	16	6
30	3994	3955	173	23	16	6
31	3994	3953	257	24	17	6
32	3994	3947	371	26	21	6
33	3993	3942	481	27	24	7
34	3993	3936	614	32	25	7
35	3993	3925	818	40	28	7
36	3993	3905	1109	59	29	7
37	3992	3871	1612	89	32	8
38	3990	3835	2221	122	33	10
39	3990	3785	2831	171	34	10
40	3990	3735	3208	216	39	10
41	3990	3658	3450	289	43	10
42	3990	3537	3433	405	48	10
43	3988	3386	3294	547	55	12
44	3983	3198	3000	718	67	17
45	3977	2892	2563	994	91	23
46	3969	2621	2162	1226	122	31
47	3958	2333	1781	1463	162	42
48	3952	2072	1468	1691	189	48
49	3940	1914	1263	1786	240	60
50	3924	1811	1118	1785	328	76

Day	Population	Susceptible	Exposed	Infected	Recovered	Dead
51	3899	1732	1008	1747	420	101
52	3858	1637	902	1664	557	142
53	3799	1567	816	1486	746	201
54	3746	1517	760	1291	938	254
55	3688	1467	699	1068	1153	312
56	3628	1407	634	863	1358	372
57	3577	1354	566	688	1535	423
58	3548	1305	1064	586	1657	452
59	3523	1260	1212	518	1745	477
60	3491	1219	1190	464	1808	509
61	3474	1174	1133	441	1859	526
62	3465	1142	1111	418	1905	535
63	3455	1098	1073	404	1953	545
64	3444	1010	940	430	2004	556
65	3432	897	824	491	2044	568
66	3426	811	754	532	2083	574
67	3416	721	670	568	2127	584
68	3407	639	596	605	2163	593
69	3395	594	576	605	2196	605
70	3389	565	549	604	2220	611
71	3383	534	511	594	2255	617
72	3371	502	482	557	2312	629
73	3356	459	441	511	2386	644
74	3331	408	387	453	2470	669
75	3315	359	323	416	2540	685
76	3303	326	299	381	2596	697
77	3292	296	275	338	2658	708
78	3278	276	252	305	2697	722
79	3272	256	228	297	2719	728
80	3269	234	196	285	2750	731

Day	Population	Susceptible	Exposed	Infected	Recovered	Dead
81	3260	218	186	262	2780	740
82	3255	202	176	238	2815	745
83	3248	191	171	203	2854	752
84	3244	178	151	176	2890	756
85	3238	172	143	153	2913	762
86	3232	162	137	133	2937	768
87	3226	148	116	116	2962	774
88	3226	137	94	116	2973	774
89	3224	130	88	104	2990	776
90	3221	118	82	100	3003	779
91	3217	109	70	93	3015	783
92	3210	99	65	85	3026	790
93	3209	94	59	82	3033	791
94	3208	90	59	77	3041	792
95	3205	88	58	69	3048	795
96	3200	78	45	65	3057	800
97	3198	75	44	59	3064	802
98	3197	71	38	55	3071	803
99	3194	69	40	48	3077	806
100	3192	63	33	46	3083	808
101	3191	58	29	40	3093	809
102	3189	54	28	40	3095	811
103	3188	54	26	35	3099	812
104	3187	51	24	34	3102	813
105	3187	47	18	30	3110	813
106	3187	43	12	30	3114	813
107	3185	40	8	29	3116	815
108	3184	40	8	27	3117	816
109	3183	39	5	24	3120	817
110	3183	38	4	19	3126	817

Day	Population	Susceptible	Exposed	Infected	Recovered	Dead
111	3183	38	4	18	3127	817
112	3182	36	1	15	3131	818
113	3181	36	1	13	3132	819
114	3180	36	1	8	3136	820
115	3180	35	0	8	3137	820
116	3179	35	0	5	3139	821
117	3179	35	0	3	3141	821
118	3179	35	0	3	3141	821
119	3179	35	0	3	3141	821
120	3179	35	1	3	3141	821
121	3179	35	2	2	3142	821
122	3179	35	2	1	3143	821
123	3179	35	2	1	3143	821
124	3179	35	2	1	3143	821
125	3179	35	2	0	3144	821
126	3179	35	2	0	3144	821
127	3179	34	1	1	3144	821
128	3179	34	2	1	3144	821
129	3179	34	1	1	3144	821
130	3179	34	1	1	3144	821
131	3179	34	1	1	3144	821
132	3179	34	1	1	3144	821
133	3179	34	2	1	3144	821
134	3179	34	2	1	3144	821
135	3179	34	2	1	3144	821
136	3179	33	1	1	3145	821
137	3179	33	1	1	3145	821
138	3179	33	1	1	3145	821
139	3179	33	1	1	3145	821
140	3179	33	1	1	3145	821

Day	**Population**	**Susceptible**	**Exposed**	**Infected**	**Recovered**	**Dead**
141	3179	33	1	1	3145	821
142	3179	33	1	1	3145	821
143	3179	33	0	0	3146	821

Table E.1: Run 01: Time series table of the total number of population, susceptible, exposed, infected, recovered, and dead agents from day 1, the start of execution to day 143, when the number of exposed and infected agents became 0.

Day	**Population**	**Susceptible**	**Exposed**	**Infected**	**Recovered**	**Dead**
1	4000	3995	0	5	0	0
2	4000	3995	0	5	0	0
3	4000	3995	0	5	0	0
4	4000	3995	1	5	0	0
5	4000	3995	2	5	0	0
6	4000	3995	3	5	0	0
7	4000	3995	8	5	0	0
8	4000	3995	15	4	1	0
9	4000	3995	15	2	3	0
10	3999	3995	15	1	3	1
11	3999	3995	15	0	4	1
12	3999	3994	17	1	4	1
13	3999	3994	17	1	4	1
14	3999	3992	24	3	4	1
15	3999	3989	36	6	4	1
16	3999	3989	37	6	4	1
17	3999	3987	37	8	4	1
18	3999	3986	35	9	4	1
19	3999	3985	37	10	4	1
20	3999	3983	48	12	4	1

Day	Population	Susceptible	Exposed	Infected	Recovered	Dead
21	3999	3979	53	15	5	1
22	3999	3977	53	15	7	1
23	3997	3973	52	17	7	3
24	3996	3970	51	18	8	4
25	3996	3968	48	20	8	4
26	3996	3964	52	22	10	4
27	3995	3959	55	25	11	5
28	3995	3959	89	25	11	5
29	3994	3957	139	25	12	6
30	3994	3953	224	26	15	6
31	3994	3950	323	25	19	6
32	3993	3947	426	26	20	7
33	3993	3944	561	25	24	7
34	3993	3937	719	29	27	7
35	3992	3927	892	35	30	8
36	3991	3900	1197	59	32	9
37	3991	3866	1631	93	32	9
38	3991	3814	2312	144	33	9
39	3989	3762	2896	191	36	11
40	3988	3697	3284	253	38	12
41	3987	3617	3428	327	43	13
42	3987	3526	3410	415	46	13
43	3985	3371	3276	560	54	15
44	3983	3139	2925	778	66	17
45	3973	2917	2575	966	90	27
46	3962	2623	2197	1218	121	38
47	3952	2328	1819	1460	164	48
48	3943	2083	1505	1653	207	57
49	3931	1904	1291	1762	265	69
50	3918	1791	1149	1790	337	82

Day	**Population**	**Susceptible**	**Exposed**	**Infected**	**Recovered**	**Dead**
51	3900	1706	1021	1746	448	100
52	3862	1623	944	1657	582	138
53	3826	1551	851	1512	763	174
54	3782	1496	789	1293	993	218
55	3721	1449	728	1046	1226	279
56	3662	1387	663	856	1419	338
57	3626	1331	596	703	1592	374
58	3600	1280	1060	597	1723	400
59	3580	1239	1192	530	1811	420
60	3564	1202	1177	486	1876	436
61	3547	1162	1142	453	1932	453
62	3531	1123	1091	410	1998	469
63	3519	1077	1037	400	2042	481
64	3508	989	932	431	2088	492
65	3500	878	820	484	2138	500
66	3491	775	722	546	2170	509
67	3480	693	649	573	2214	520
68	3465	625	593	600	2240	535
69	3458	577	559	605	2276	542
70	3453	548	529	597	2308	547
71	3441	514	504	586	2341	559
72	3426	472	450	569	2385	574
73	3409	433	411	514	2462	591
74	3394	397	373	451	2546	606
75	3368	365	344	382	2621	632
76	3353	324	302	352	2677	647
77	3338	299	263	313	2726	662
78	3324	284	255	281	2759	676
79	3319	258	233	273	2788	681
80	3313	241	206	253	2819	687

Day	Population	Susceptible	Exposed	Infected	Recovered	Dead
81	3307	222	187	239	2846	693
82	3297	206	181	207	2884	703
83	3292	193	168	190	2909	708
84	3285	184	157	166	2935	715
85	3281	176	144	146	2959	719
86	3271	159	129	133	2979	729
87	3264	146	118	123	2995	736
88	3261	131	106	122	3008	739
89	3258	120	88	116	3022	742
90	3256	111	80	109	3036	744
91	3253	105	78	101	3047	747
92	3250	91	65	101	3058	750
93	3246	82	62	97	3067	754
94	3242	78	58	88	3076	758
95	3240	71	49	83	3086	760
96	3237	67	50	77	3093	763
97	3235	63	44	63	3109	765
98	3235	55	36	60	3120	765
99	3234	53	32	56	3125	766
100	3229	47	24	53	3129	771
101	3228	47	25	42	3139	772
102	3226	46	24	36	3144	774
103	3225	41	19	34	3150	775
104	3223	38	15	32	3153	777
105	3223	37	12	29	3157	777
106	3222	36	11	24	3162	778
107	3221	32	7	22	3167	779
108	3220	30	5	20	3170	780
109	3219	29	4	20	3170	781
110	3218	28	3	18	3172	782

Day	Population	Susceptible	Exposed	Infected	Recovered	Dead
111	3218	27	2	18	3173	782
112	3217	27	1	15	3175	783
113	3216	26	0	12	3178	784
114	3216	26	0	12	3178	784
115	3215	26	0	10	3179	785
116	3214	26	0	7	3181	786
117	3213	26	0	5	3182	787
118	3212	26	0	3	3183	788
119	3211	26	0	0	3185	789

Table E.2: Run 02: Time series table of the total number of population, susceptible, exposed, infected, recovered, and dead agents from day 1, the start of execution to day 119, when the number of exposed and infected agents became 0.

Day	Population	Susceptible	Exposed	Infected	Recovered	Dead
1	4000	3995	0	5	0	0
2	4000	3995	0	5	0	0
3	4000	3995	4	5	0	0
4	4000	3995	5	5	0	0
5	4000	3995	7	5	0	0
6	4000	3995	18	5	0	0
7	4000	3995	23	5	0	0
8	4000	3995	25	5	0	0
9	4000	3995	26	2	3	0
10	4000	3994	25	1	5	0
11	4000	3992	30	3	5	0
12	4000	3988	28	7	5	0
13	4000	3986	34	9	5	0
14	4000	3986	62	9	5	0
15	4000	3982	62	13	5	0
16	4000	3981	61	14	5	0
17	4000	3979	65	16	5	0
18	4000	3976	67	19	5	0
19	4000	3974	63	19	7	0
20	3999	3970	72	18	11	1

Day	**Population**	**Susceptible**	**Exposed**	**Infected**	**Recovered**	**Dead**
21	3999	3965	74	23	11	1
22	3997	3961	70	25	11	3
23	3997	3960	70	25	12	3
24	3996	3952	74	30	14	4
25	3996	3948	79	31	17	4
26	3996	3947	79	31	18	4
27	3994	3945	78	31	18	6
28	3994	3941	135	31	22	6
29	3993	3930	249	37	26	7
30	3993	3922	423	43	28	7
31	3990	3917	664	43	30	10
32	3990	3913	930	43	34	10
33	3989	3907	1234	46	36	11
34	3988	3888	1569	62	38	12
35	3988	3856	2017	89	43	12
36	3986	3813	2524	129	44	14
37	3984	3733	2995	202	49	16
38	3984	3628	3279	300	56	16
39	3982	3505	3335	415	62	18
40	3981	3337	3224	576	68	19
41	3980	3165	3077	743	72	20
42	3976	2935	2887	959	82	24
43	3973	2719	2679	1154	100	27
44	3961	2445	2303	1390	126	39
45	3950	2204	1984	1570	176	50
46	3935	2028	1725	1659	248	65
47	3916	1858	1495	1708	350	84
48	3894	1708	1307	1731	455	106
49	3856	1591	1168	1694	571	144
50	3815	1485	1024	1596	734	185

Day	Population	Susceptible	Exposed	Infected	Recovered	Dead
51	3776	1396	891	1451	929	224
52	3732	1311	789	1292	1129	268
53	3683	1240	692	1130	1313	317
54	3648	1182	615	991	1475	352
55	3611	1127	556	847	1637	389
56	3586	1080	496	743	1763	414
57	3557	1031	449	649	1877	443
58	3531	990	776	572	1969	469
59	3510	953	891	507	2050	490
60	3488	918	889	445	2125	512
61	3472	887	869	398	2187	528
62	3453	861	844	355	2237	547
63	3444	833	801	338	2273	556
64	3428	768	714	336	2324	572
65	3423	701	627	358	2364	577
66	3415	623	562	388	2404	585
67	3410	543	487	431	2436	590
68	3404	472	436	471	2461	596
69	3402	441	417	472	2489	598
70	3396	414	402	467	2515	604
71	3388	399	385	451	2538	612
72	3379	382	360	421	2576	621
73	3369	350	322	391	2628	631
74	3357	320	297	354	2683	643
75	3341	295	259	301	2745	659
76	3318	271	249	241	2806	682
77	3309	243	211	221	2845	691
78	3305	227	200	205	2873	695
79	3299	203	180	207	2889	701
80	3299	191	168	200	2908	701

Day	Population	Susceptible	Exposed	Infected	Recovered	Dead
81	3293	177	149	194	2922	707
82	3284	167	141	172	2945	716
83	3276	154	123	158	2964	724
84	3268	134	105	153	2981	732
85	3261	120	92	138	3003	739
86	3258	111	83	125	3022	742
87	3255	105	78	116	3034	745
88	3251	97	70	107	3047	749
89	3249	86	60	100	3063	751
90	3242	81	58	90	3071	758
91	3240	78	55	78	3084	760
92	3237	74	50	71	3092	763
93	3235	72	51	59	3104	765
94	3233	65	48	53	3115	767
95	3232	61	40	46	3125	768
96	3230	56	35	44	3130	770
97	3229	51	31	42	3136	771
98	3228	43	24	43	3142	772
99	3226	40	20	42	3144	774
100	3225	38	18	41	3146	775
101	3223	35	13	40	3148	777
102	3221	31	11	38	3152	779
103	3219	29	9	32	3158	781
104	3217	28	9	29	3160	783
105	3217	26	7	28	3163	783
106	3216	26	7	25	3165	784
107	3215	26	7	18	3171	785
108	3212	24	5	15	3173	788
109	3212	24	5	11	3177	788
110	3211	21	2	12	3178	789

Day	Population	Susceptible	Exposed	Infected	Recovered	Dead
111	3211	21	1	12	3178	789
112	3210	20	0	9	3181	790
113	3210	20	0	8	3182	790
114	3210	20	0	6	3184	790
115	3210	20	0	6	3184	790
116	3210	20	0	5	3185	790
117	3210	20	0	5	3185	790
118	3210	20	0	4	3186	790
119	3210	20	0	3	3187	790
120	3210	20	0	0	3190	790

Table E.3: Run 03: Time series table of the total number of population, susceptible, exposed, infected, recovered, and dead agents from day 1, the start of execution to day 120, when the number of exposed and infected agents became 0.

Day	Population	Susceptible	Exposed	Infected	Recovered	Dead
1	4000	3995	0	5	0	0
2	4000	3995	0	5	0	0
3	4000	3995	0	5	0	0
4	4000	3995	0	5	0	0
5	4000	3995	4	5	0	0
6	4000	3995	7	5	0	0
7	4000	3995	10	5	0	0
8	4000	3995	16	5	0	0
9	3997	3995	21	2	0	3
10	3997	3995	21	0	2	3
11	3997	3994	20	1	2	3
12	3997	3992	23	3	2	3
13	3997	3991	26	4	2	3
14	3997	3987	41	8	2	3
15	3997	3984	41	11	2	3
16	3997	3981	37	14	2	3
17	3997	3981	42	14	2	3
18	3997	3980	41	15	2	3
19	3997	3979	40	16	2	3
20	3997	3976	42	19	2	3

Day	Population	Susceptible	Exposed	Infected	Recovered	Dead
21	3997	3971	47	21	5	3
22	3997	3964	54	25	8	3
23	3997	3962	54	26	9	3
24	3997	3959	56	25	13	3
25	3997	3958	55	24	15	3
26	3997	3956	54	25	16	3
27	3996	3952	50	28	16	4
28	3996	3946	117	31	19	4
29	3995	3944	219	30	21	5
30	3994	3938	323	30	26	6
31	3993	3935	461	29	29	7
32	3993	3931	616	32	30	7
33	3992	3925	794	35	32	8
34	3992	3909	1019	49	34	8
35	3992	3887	1388	68	37	8
36	3992	3847	1947	103	42	8
37	3991	3794	2580	152	45	9
38	3991	3725	3056	215	51	9
39	3991	3627	3355	309	55	9
40	3990	3525	3403	409	56	10
41	3990	3402	3315	529	59	10
42	3987	3216	3149	705	66	13
43	3980	2989	2922	911	80	20
44	3970	2733	2541	1133	104	30
45	3957	2441	2113	1376	140	43
46	3946	2188	1791	1574	184	54
47	3928	2003	1546	1686	239	72
48	3910	1841	1335	1743	326	90
49	3883	1712	1184	1746	425	117
50	3857	1617	1055	1701	539	143

Day	Population	Susceptible	Exposed	Infected	Recovered	Dead
51	3801	1534	951	1570	697	199
52	3763	1450	845	1420	893	237
53	3700	1384	764	1226	1090	300
54	3660	1336	694	1009	1315	340
55	3616	1301	638	837	1478	384
56	3581	1252	559	699	1630	419
57	3548	1209	496	597	1742	452
58	3517	1162	864	520	1835	483
59	3492	1124	1047	461	1907	508
60	3483	1085	1052	420	1978	517
61	3467	1059	1036	377	2031	533
62	3453	1027	1006	349	2077	547
63	3441	987	958	339	2115	559
64	3434	927	863	359	2148	566
65	3420	851	776	383	2186	580
66	3418	774	700	421	2223	582
67	3407	682	629	466	2259	593
68	3400	601	552	511	2288	600
69	3395	566	533	517	2312	605
70	3387	541	522	507	2339	613
71	3383	507	490	505	2371	617
72	3370	470	446	483	2417	630
73	3360	426	405	462	2472	640
74	3351	395	371	427	2529	649
75	3342	356	325	404	2582	658
76	3328	313	281	360	2655	672
77	3316	279	250	324	2713	684
78	3303	257	234	303	2743	697
79	3295	244	222	284	2767	705
80	3289	228	209	271	2790	711

Day	Population	Susceptible	Exposed	Infected	Recovered	Dead
81	3282	214	190	244	2824	718
82	3274	199	177	213	2862	726
83	3273	188	167	189	2896	727
84	3267	171	141	168	2928	733
85	3260	154	118	147	2959	740
86	3254	145	109	129	2980	746
87	3250	132	96	124	2994	750
88	3247	119	78	120	3008	753
89	3241	112	78	112	3017	759
90	3238	104	74	103	3031	762
91	3233	96	73	94	3043	767
92	3230	91	72	90	3049	770
93	3230	87	68	81	3062	770
94	3227	76	58	76	3075	773
95	3224	73	52	65	3086	776
96	3222	68	46	58	3096	778
97	3219	66	38	48	3105	781
98	3217	61	32	45	3111	783
99	3216	58	25	43	3115	784
100	3215	53	18	41	3121	785
101	3213	52	18	38	3123	787
102	3212	49	17	34	3129	788
103	3211	49	19	25	3137	789
104	3208	46	14	25	3137	792
105	3208	46	14	24	3138	792
106	3205	44	12	18	3143	795
107	3205	40	8	22	3143	795
108	3205	39	6	17	3149	795
109	3204	37	4	16	3151	796
110	3204	35	2	16	3153	796

Day	**Population**	**Susceptible**	**Exposed**	**Infected**	**Recovered**	**Dead**
111	3204	34	1	16	3154	796
112	3203	33	0	15	3155	797
113	3203	33	0	14	3156	797
114	3202	33	0	12	3157	798
115	3202	33	0	11	3158	798
116	3201	33	0	7	3161	799
117	3201	33	0	5	3163	799
118	3201	33	0	4	3164	799
119	3201	33	0	4	3164	799
120	3201	33	0	2	3166	799
121	3201	33	0	1	3167	799
122	3201	33	0	0	3168	799

Table E.4: Run 04: Time series table of the total number of population, susceptible, exposed, infected, recovered, and dead agents from day 1, the start of execution to day 122, when the number of exposed and infected agents became 0.

Day	**Population**	**Susceptible**	**Exposed**	**Infected**	**Recovered**	**Dead**
1	4000	3995	0	5	0	0
2	4000	3995	2	5	0	0
3	4000	3995	4	5	0	0
4	4000	3995	4	5	0	0
5	4000	3995	4	5	0	0
6	4000	3995	6	5	0	0
7	4000	3995	6	5	0	0
8	4000	3995	10	5	0	0
9	3999	3995	12	3	1	1
10	3999	3995	20	1	3	1
11	3999	3995	20	0	4	1
12	3999	3993	20	2	4	1
13	3999	3992	26	3	4	1
14	3999	3991	41	4	4	1
15	3999	3989	39	6	4	1
16	3999	3988	36	7	4	1
17	3999	3986	40	9	4	1
18	3999	3986	41	9	4	1
19	3999	3984	37	11	4	1
20	3999	3983	42	12	4	1

Day	Population	Susceptible	Exposed	Infected	Recovered	Dead
21	3998	3981	46	13	4	2
22	3998	3980	48	12	6	2
23	3998	3977	47	14	7	2
24	3998	3974	45	15	9	2
25	3997	3972	46	16	9	3
26	3997	3971	43	16	10	3
27	3996	3968	39	18	10	4
28	3996	3962	71	21	13	4
29	3996	3960	130	22	14	4
30	3996	3958	194	22	16	4
31	3996	3953	296	26	17	4
32	3996	3950	419	26	20	4
33	3995	3946	552	26	23	5
34	3994	3941	708	29	24	6
35	3993	3923	933	46	24	7
36	3993	3896	1317	72	25	7
37	3992	3843	1922	120	29	8
38	3992	3803	2619	155	34	8
39	3992	3747	3076	209	36	8
40	3989	3672	3419	279	38	11
41	3989	3588	3464	360	41	11
42	3989	3476	3390	468	45	11
43	3989	3262	3180	670	57	11
44	3982	3014	2815	891	77	18
45	3976	2737	2404	1144	95	24
46	3965	2459	2024	1365	141	35
47	3959	2190	1685	1582	187	41
48	3947	2000	1433	1720	227	53
49	3923	1861	1255	1779	283	77
50	3899	1744	1128	1785	370	101

Day	Population	Susceptible	Exposed	Infected	Recovered	Dead
51	3870	1659	1016	1722	489	130
52	3829	1590	937	1597	642	171
53	3778	1533	865	1397	848	222
54	3711	1470	788	1154	1087	289
55	3664	1412	726	951	1301	336
56	3615	1363	663	773	1479	385
57	3584	1301	584	658	1625	416
58	3557	1252	1022	575	1730	443
59	3531	1209	1161	518	1804	469
60	3518	1175	1144	470	1873	482
61	3509	1138	1112	434	1937	491
62	3496	1103	1084	410	1983	504
63	3483	1066	1028	383	2034	517
64	3476	983	914	411	2082	524
65	3467	888	835	455	2124	533
66	3453	792	730	492	2169	547
67	3443	691	630	552	2200	557
68	3427	620	583	577	2230	573
69	3421	573	555	596	2252	579
70	3411	538	525	591	2282	589
71	3405	503	493	595	2307	595
72	3390	461	443	561	2368	610
73	3369	425	406	524	2420	631
74	3350	378	359	473	2499	650
75	3323	340	310	395	2588	677
76	3312	303	261	368	2641	688
77	3296	283	258	321	2692	704
78	3290	259	237	303	2728	710
79	3283	240	217	281	2762	717
80	3275	222	196	254	2799	725

Day	**Population**	**Susceptible**	**Exposed**	**Infected**	**Recovered**	**Dead**
81	3271	207	183	240	2824	729
82	3267	190	168	219	2858	733
83	3263	172	148	196	2895	737
84	3257	148	118	179	2930	743
85	3251	136	110	162	2953	749
86	3244	123	98	148	2973	756
87	3242	118	91	134	2990	758
88	3240	106	75	127	3007	760
89	3239	101	71	116	3022	761
90	3237	97	66	104	3036	763
91	3234	90	61	92	3052	766
92	3232	84	57	78	3070	768
93	3227	81	48	62	3084	773
94	3225	74	43	57	3094	775
95	3220	72	41	51	3097	780
96	3219	68	39	51	3100	781
97	3216	67	38	39	3110	784
98	3213	65	37	35	3113	787
99	3211	60	29	35	3116	789
100	3209	55	25	34	3120	791
101	3206	52	23	28	3126	794
102	3205	51	23	26	3128	795
103	3204	48	21	27	3129	796
104	3203	45	20	25	3133	797
105	3203	43	17	26	3134	797
106	3203	41	13	25	3137	797
107	3203	40	10	22	3141	797
108	3203	39	8	20	3144	797
109	3203	38	6	17	3148	797
110	3203	37	5	16	3150	797

Day	Population	Susceptible	Exposed	Infected	Recovered	Dead
111	3201	35	3	15	3151	799
112	3200	34	1	13	3153	800
113	3199	34	1	9	3156	801
114	3199	34	1	7	3158	801
115	3198	34	0	6	3158	802
116	3198	34	0	5	3159	802
117	3198	34	0	5	3159	802
118	3198	34	0	0	3162	804

Table E.5: Run 05: Time series table of the total number of population, susceptible, exposed, infected, recovered, and dead agents from day 1, the start of execution to day 118, when the number of exposed and infected agents became 0.

Appendix F

Figures for Scenario 02.2

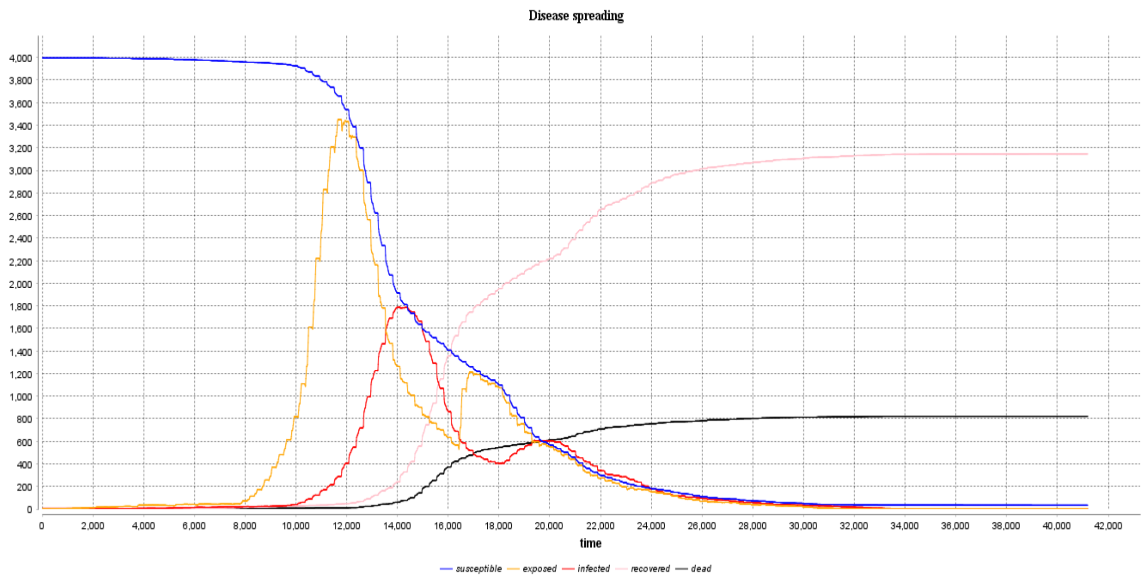

Figure F.1: Time Series chart of Scenario 02.2 Run 01.

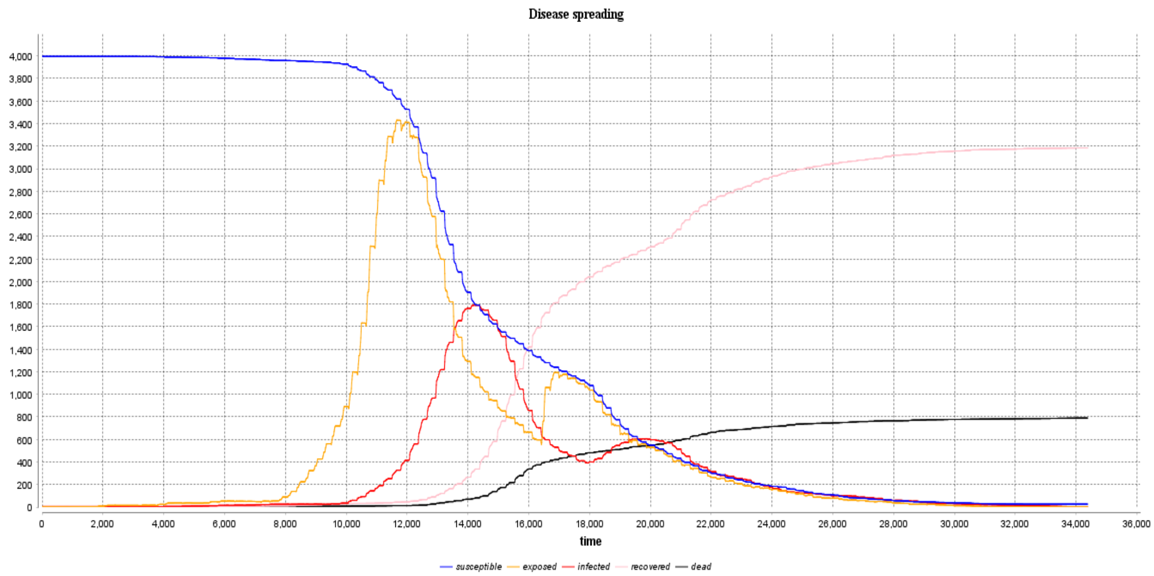

Figure F.2: Time Series chart of Scenario 02.2 Run 02.

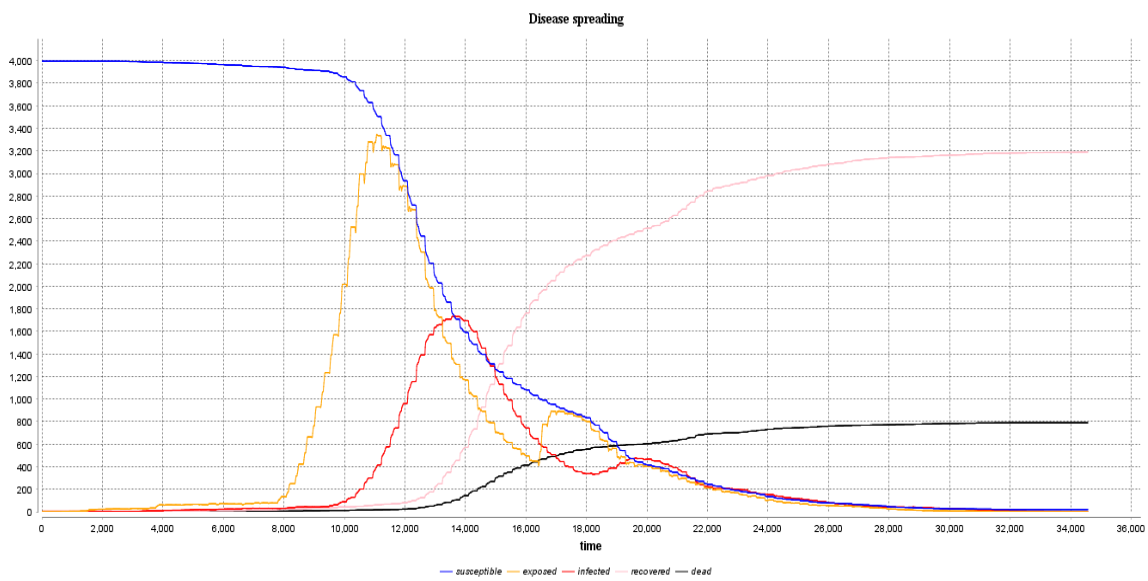

Figure F.3: Time Series chart of Scenario 02.2 Run 03.

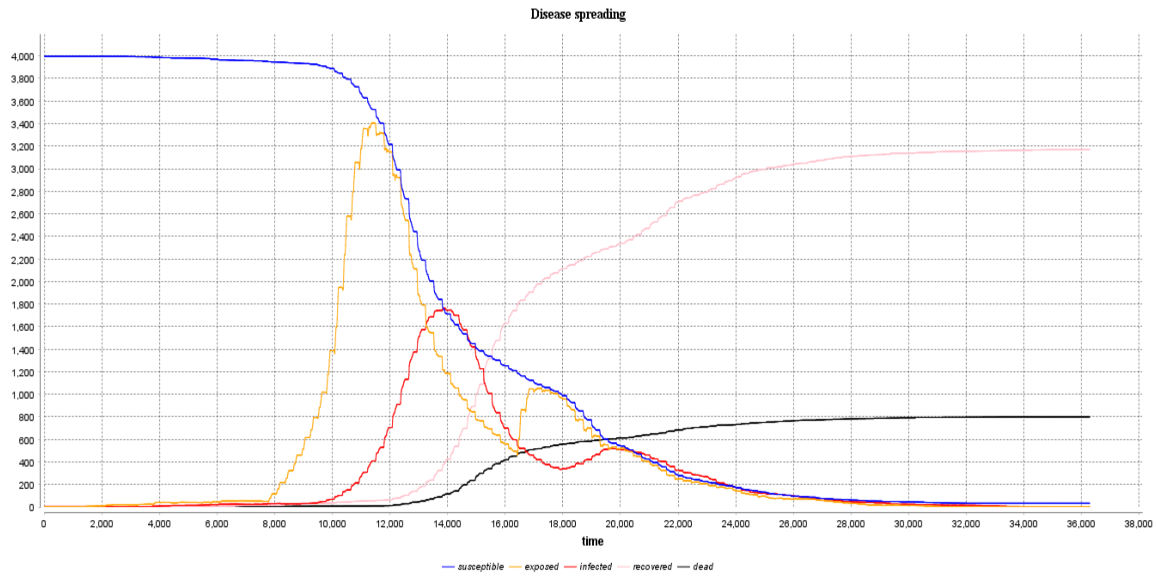

Figure F.4: Time Series chart of Scenario 02.2 Run 04.

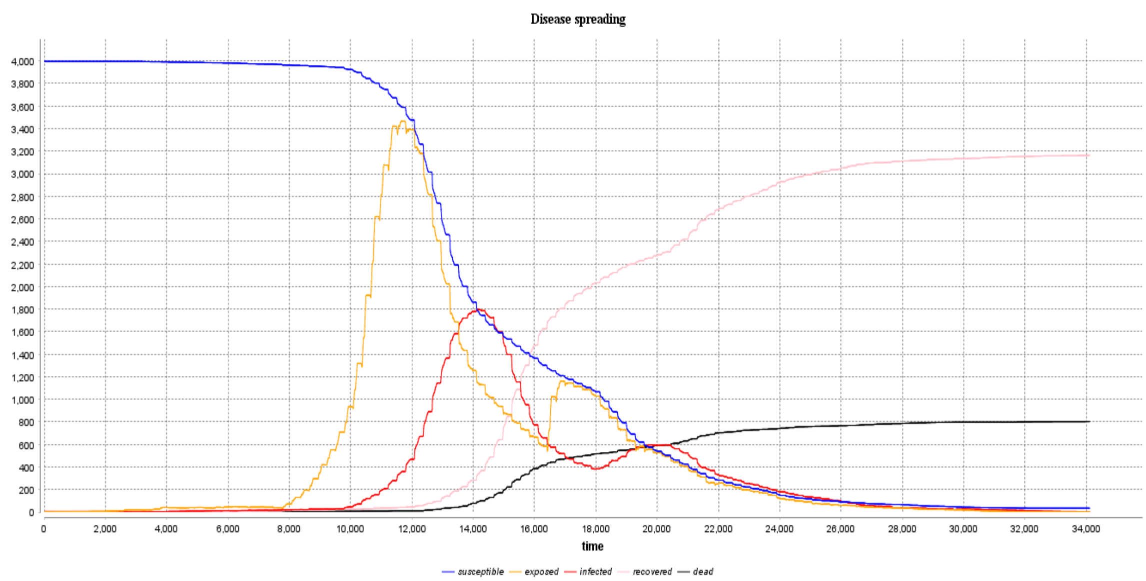

Figure F.5: Time Series chart of Scenario 02.2 Run 05.

Appendix G

Table for Scenario 03

Day	Population	Susceptible	Exposed	Infected	Recovered	Dead
1	4000	3995	0	5	0	0
2	4000	3995	2	5	0	0
3	4000	3995	2	5	0	0
4	4000	3995	5	5	0	0
5	4000	3995	7	5	0	0
6	4000	3995	11	5	0	0
7	4000	3995	14	5	0	0
8	4000	3995	14	4	1	0
9	4000	3995	14	2	3	0
10	3999	3994	13	2	3	1
11	3999	3994	12	1	4	1
12	3999	3993	9	2	4	1
13	3999	3991	8	4	4	1
14	3999	3990	11	5	4	1
15	3999	3988	16	7	4	1
16	3999	3987	17	8	4	1
17	3999	3987	20	8	4	1
18	3999	3987	24	7	5	1
19	3999	3986	26	8	5	1
20	3999	3984	31	10	5	1

Day	**Population**	**Susceptible**	**Exposed**	**Infected**	**Recovered**	**Dead**
21	3999	3982	37	12	5	1
22	3996	3982	39	6	8	4
23	3996	3978	42	10	8	4
24	3996	3973	54	15	8	4
25	3996	3973	66	14	9	4
26	3996	3970	74	17	9	4
27	3996	3966	95	19	11	4
28	3996	3960	117	24	12	4
29	3996	3958	145	25	13	4
30	3996	3953	170	29	14	4
31	3996	3950	226	30	16	4
32	3996	3946	272	32	18	4
33	3996	3934	341	42	20	4
34	3995	3927	462	45	23	5
35	3995	3912	605	54	29	5
36	3995	3896	748	65	34	5
37	3995	3876	980	82	37	5
38	3994	3855	1208	99	40	6
39	3993	3818	1536	132	43	7
40	3992	3776	1914	171	45	8
41	3991	3719	2314	223	49	9
42	3988	3653	2657	278	57	12
43	3987	3541	2911	375	71	13
44	3985	3433	3042	471	81	15
45	3983	3275	2995	615	93	17
46	3982	3118	2861	746	118	18
47	3975	2903	2697	929	143	25
48	3968	2648	2472	1151	169	32
49	3958	2436	2228	1308	214	42
50	3942	2202	2010	1472	268	58

Day	**Population**	**Susceptible**	**Exposed**	**Infected**	**Recovered**	**Dead**
51	3930	2006	1834	1587	337	70
52	3913	1843	1685	1631	439	87
53	3882	1708	1578	1617	557	118
54	3850	1584	1471	1592	674	150
55	3806	1459	1341	1518	829	194
56	3765	1324	1220	1436	1005	235
57	3727	1221	1090	1314	1192	273
58	3673	1123	996	1159	1391	327
59	3639	1019	889	1078	1542	361
60	3615	927	811	1007	1681	385
61	3586	846	747	935	1805	414
62	3569	774	670	868	1927	431
63	3546	708	618	816	2022	454
64	3518	651	551	730	2137	482
65	3492	597	491	680	2215	508
66	3472	541	437	627	2304	528
67	3449	491	384	571	2387	551
68	3430	457	362	515	2458	570
69	3409	420	329	465	2524	591
70	3391	393	306	417	2581	609
71	3376	364	275	376	2636	624
72	3362	339	239	335	2688	638
73	3353	326	225	299	2728	647
74	3346	301	198	266	2779	654
75	3341	279	167	242	2820	659
76	3333	265	158	212	2856	667
77	3328	245	136	189	2894	672
78	3326	232	132	176	2918	674
79	3325	218	127	161	2946	675
80	3321	208	114	147	2966	679

Day	**Population**	**Susceptible**	**Exposed**	**Infected**	**Recovered**	**Dead**
81	3314	198	104	132	2984	686
82	3312	186	97	125	3001	688
83	3307	180	88	113	3014	693
84	3306	167	80	109	3030	694
85	3302	159	79	97	3046	698
86	3300	145	72	102	3053	700
87	3295	139	66	85	3071	705
88	3294	137	60	76	3081	706
89	3294	130	53	76	3088	706
90	3292	129	47	61	3102	708
91	3291	121	42	59	3111	709
92	3290	120	36	53	3117	710
93	3288	116	29	43	3129	712
94	3286	112	24	40	3134	714
95	3285	110	26	36	3139	715
96	3285	107	20	30	3148	715
97	3284	105	17	28	3151	716
98	3282	103	20	25	3154	718
99	3282	103	18	23	3156	718
100	3282	102	13	20	3160	718
101	3281	101	13	16	3164	719
102	3281	101	12	15	3165	719
103	3280	99	13	13	3168	720
104	3280	98	10	12	3170	720
105	3280	97	8	10	3173	720
106	3280	97	7	7	3176	720
107	3279	97	6	6	3176	721
108	3279	97	6	5	3177	721
109	3279	97	5	4	3178	721
110	3279	97	4	4	3178	721

Day	Population	Susceptible	Exposed	Infected	Recovered	Dead
111	3279	96	4	3	3180	721
112	3279	95	3	4	3180	721
113	3279	93	2	5	3181	721
114	3279	93	2	5	3181	721
115	3278	93	3	4	3181	722
116	3278	92	3	5	3181	722
117	3278	92	3	5	3181	722
118	3278	92	3	5	3181	722
119	3278	92	2	5	3181	722
120	3278	91	1	3	3184	722
121	3278	91	1	2	3185	722
122	3278	90	0	3	3185	722
123	3278	90	1	3	3185	722
124	3278	90	1	3	3185	722
125	3278	90	1	2	3186	722
126	3278	90	1	2	3186	722
127	3278	90	1	2	3186	722
128	3278	89	0	3	3186	722
129	3278	89	1	2	3187	722
130	3278	89	1	2	3187	722
131	3278	89	1	1	3188	722
132	3278	89	1	1	3188	722
133	3278	89	1	1	3188	722
134	3278	89	1	1	3188	722
135	3278	89	1	1	3188	722
136	3278	89	1	1	3188	722
137	3278	88	0	1	3189	722
138	3278	88	1	1	3189	722
139	3278	88	1	1	3189	722
140	3278	88	1	1	3189	722

Day	Population	Susceptible	Exposed	Infected	Recovered	Dead
141	3278	88	1	1	3189	722
142	3278	88	1	1	3189	722
143	3278	88	1	1	3189	722
144	3278	88	0	1	3189	722
145	3278	88	0	0	3190	722

Table G.1: Run 01: Time series table of the total number of population, susceptible, exposed, infected, recovered, and dead agents from day 1, the start of execution to day 145, when the number of exposed and infected agents became 0.

Day	Population	Susceptible	Exposed	Infected	Recovered	Dead
1	4000	3995	0	5	0	0
2	4000	3995	0	5	0	0
3	4000	3995	1	5	0	0
4	4000	3995	4	5	0	0
5	4000	3995	5	5	0	0
6	4000	3995	6	5	0	0
7	4000	3995	7	5	0	0
8	4000	3995	7	5	0	0
9	4000	3995	7	2	3	0
10	3998	3994	7	1	3	2
11	3998	3994	7	1	3	2
12	3998	3992	6	3	3	2
13	3998	3990	9	5	3	2
14	3998	3989	8	6	3	2
15	3998	3989	9	6	3	2
16	3998	3988	12	7	3	2
17	3998	3988	15	7	3	2
18	3998	3987	17	8	3	2
19	3998	3986	20	8	4	2
20	3998	3986	24	7	5	2

Day	Population	Susceptible	Exposed	Infected	Recovered	Dead
21	3998	3985	22	6	7	2
22	3997	3985	21	4	8	3
23	3997	3984	24	5	8	3
24	3997	3984	26	5	8	3
25	3996	3981	29	7	8	4
26	3996	3978	37	9	9	4
27	3995	3974	52	12	9	5
28	3995	3973	58	12	10	5
29	3995	3970	64	15	10	5
30	3995	3969	78	16	10	5
31	3995	3963	105	21	11	5
32	3995	3958	137	25	12	5
33	3994	3954	175	28	12	6
34	3994	3948	236	32	14	6
35	3994	3940	285	37	17	6
36	3994	3934	376	41	19	6
37	3994	3927	472	45	22	6
38	3994	3912	574	57	25	6
39	3994	3900	713	65	29	6
40	3994	3871	948	90	33	6
41	3993	3837	1273	120	36	7
42	3991	3803	1656	149	39	9
43	3987	3763	2021	179	45	13
44	3987	3707	2392	230	50	13
45	3985	3641	2715	289	55	15
46	3984	3562	2966	356	66	16
47	3980	3448	3052	459	73	20
48	3977	3279	2994	603	95	23
49	3971	3075	2846	773	123	29
50	3965	2841	2629	972	152	35

Day	**Population**	**Susceptible**	**Exposed**	**Infected**	**Recovered**	**Dead**
51	3953	2617	2417	1151	185	47
52	3940	2390	2189	1332	218	60
53	3931	2172	1990	1489	270	69
54	3912	1971	1825	1617	324	88
55	3887	1806	1667	1666	415	113
56	3860	1669	1524	1666	525	140
57	3834	1548	1414	1604	682	166
58	3792	1423	1299	1523	846	208
59	3751	1323	1187	1396	1032	249
60	3708	1220	1074	1274	1214	292
61	3664	1115	976	1166	1383	336
62	3621	1027	898	1038	1556	379
63	3589	941	808	958	1690	411
64	3563	863	748	875	1825	437
65	3539	794	675	807	1938	461
66	3517	735	605	745	2037	483
67	3497	673	558	695	2129	503
68	3467	619	514	626	2222	533
69	3446	569	457	590	2287	554
70	3427	536	419	533	2358	573
71	3413	491	371	497	2425	587
72	3394	458	354	454	2482	606
73	3383	428	324	412	2543	617
74	3367	396	291	367	2604	633
75	3354	367	270	341	2646	646
76	3342	345	241	297	2700	658
77	3335	322	211	272	2741	665
78	3323	306	186	247	2770	677
79	3318	287	180	221	2810	682
80	3314	268	161	208	2838	686

Day	**Population**	**Susceptible**	**Exposed**	**Infected**	**Recovered**	**Dead**
81	3303	250	150	193	2860	697
82	3294	237	135	173	2884	706
83	3287	222	132	162	2903	713
84	3280	210	122	145	2925	720
85	3277	206	117	129	2942	723
86	3273	194	107	121	2958	727
87	3269	186	100	110	2973	731
88	3267	179	90	102	2986	733
89	3263	172	82	94	2997	737
90	3258	165	80	75	3018	742
91	3254	157	73	68	3029	746
92	3254	152	64	64	3038	746
93	3254	145	55	60	3049	746
94	3250	139	50	59	3052	750
95	3249	136	44	55	3058	751
96	3249	134	42	51	3064	751
97	3247	127	33	50	3070	753
98	3246	123	29	45	3078	754
99	3245	120	27	42	3083	755
100	3243	119	28	34	3090	757
101	3243	114	20	34	3095	757
102	3240	113	22	29	3098	760
103	3240	110	21	28	3102	760
104	3239	108	17	25	3106	761
105	3237	106	15	21	3110	763
106	3235	103	13	22	3110	765
107	3235	101	14	22	3112	765
108	3234	101	14	18	3115	766
109	3232	101	16	13	3118	768
110	3231	99	13	14	3118	769

Day	Population	Susceptible	Exposed	Infected	Recovered	Dead
111	3231	97	11	15	3119	769
112	3229	96	12	12	3121	771
113	3229	96	9	9	3124	771
114	3229	96	10	9	3124	771
115	3229	95	9	8	3126	771
116	3229	93	6	8	3128	771
117	3228	93	5	6	3129	772
118	3228	93	6	6	3129	772
119	3228	93	6	6	3129	772
120	3226	92	5	5	3129	774
121	3226	92	4	5	3129	774
122	3226	92	2	4	3130	774
123	3226	92	2	4	3130	774
124	3226	92	1	2	3132	774
125	3226	92	0	2	3132	774
126	3226	92	0	1	3133	774
127	3226	92	2	1	3133	774
128	3226	92	2	1	3133	774
129	3226	92	2	0	3134	774
130	3226	92	2	0	3134	774
131	3226	92	2	0	3134	774
132	3226	92	2	0	3134	774
133	3226	92	2	0	3134	774
134	3226	92	2	0	3134	774
135	3226	92	2	0	3134	774
136	3226	92	2	0	3134	774
137	3226	90	0	2	3134	774
138	3226	90	0	2	3134	774
139	3226	90	0	2	3134	774
140	3226	90	0	2	3134	774

Day	**Population**	**Susceptible**	**Exposed**	**Infected**	**Recovered**	**Dead**
141	3226	90	0	2	3134	774
142	3226	90	0	2	3134	774
143	3226	90	0	2	3134	774
144	3226	90	0	0	3135	775

Table G.2: Run 02: Time series table of the total number of population, susceptible, exposed, infected, recovered, and dead agents from day 1, the start of execution to day 144, when the number of exposed and infected agents became 0.

Day	Population	Susceptible	Exposed	Infected	Recovered	Dead
1	4000	3995	0	5	0	0
2	4000	3995	0	5	0	0
3	4000	3995	0	5	0	0
4	4000	3995	2	5	0	0
5	4000	3995	2	5	0	0
6	4000	3995	4	5	0	0
7	4000	3995	6	5	0	0
8	3999	3995	6	3	1	1
9	3999	3995	5	1	3	1
10	3999	3995	5	0	4	1
11	3999	3995	5	0	4	1
12	3999	3995	5	0	4	1
13	3999	3994	4	1	4	1
14	3999	3994	3	1	4	1
15	3999	3993	4	2	4	1
16	3999	3992	5	3	4	1
17	3999	3992	5	3	4	1
18	3999	3992	5	3	4	1
19	3999	3992	6	3	4	1
20	3998	3992	6	2	4	2

Day	**Population**	**Susceptible**	**Exposed**	**Infected**	**Recovered**	**Dead**
21	3998	3991	5	3	4	2
22	3998	3991	5	3	4	2
23	3998	3989	6	5	4	2
24	3998	3989	7	4	5	2
25	3998	3988	8	4	6	2
26	3998	3988	9	4	6	2
27	3998	3988	11	4	6	2
28	3998	3988	11	4	6	2
29	3998	3988	12	3	7	2
30	3998	3987	17	3	8	2
31	3998	3986	22	3	9	2
32	3998	3984	24	5	9	2
33	3998	3981	34	8	9	2
34	3998	3980	38	8	10	2
35	3998	3980	45	8	10	2
36	3998	3979	52	9	10	2
37	3998	3978	59	10	10	2
38	3997	3971	82	16	10	3
39	3997	3967	108	19	11	3
40	3997	3962	122	24	11	3
41	3996	3957	159	24	15	4
42	3996	3954	198	27	15	4
43	3996	3949	232	31	16	4
44	3996	3945	283	34	17	4
45	3996	3935	365	44	17	4
46	3996	3918	489	58	20	4
47	3993	3900	663	67	26	7
48	3991	3881	879	84	26	9
49	3991	3857	1142	102	32	9
50	3991	3836	1382	118	37	9

Day	**Population**	**Susceptible**	**Exposed**	**Infected**	**Recovered**	**Dead**
51	3991	3801	1730	149	41	9
52	3991	3761	2087	186	44	9
53	3988	3695	2483	247	46	12
54	3984	3610	2794	318	56	16
55	3981	3510	2987	397	74	19
56	3979	3373	3016	516	90	21
57	3976	3195	2926	674	107	24
58	3972	2999	2774	844	129	28
59	3965	2779	2589	1034	152	35
60	3955	2554	2355	1221	180	45
61	3947	2319	2130	1406	222	53
62	3934	2100	1952	1542	292	66
63	3911	1915	1753	1628	368	89
64	3889	1726	1587	1687	476	111
65	3849	1584	1462	1675	590	151
66	3796	1472	1340	1602	722	204
67	3753	1368	1248	1500	885	247
68	3704	1274	1148	1385	1045	296
69	3659	1170	1054	1260	1229	341
70	3615	1051	944	1153	1411	385
71	3575	951	835	1037	1587	425
72	3546	880	762	934	1732	454
73	3512	796	680	858	1858	488
74	3486	732	624	794	1960	514
75	3474	673	576	753	2048	526
76	3447	613	518	704	2130	553
77	3428	564	468	644	2220	572
78	3405	521	422	597	2287	595
79	3388	486	384	527	2375	612
80	3368	448	344	477	2443	632

Day	Population	Susceptible	Exposed	Infected	Recovered	Dead
81	3349	416	312	428	2505	651
82	3340	377	267	392	2571	660
83	3334	351	254	355	2628	666
84	3320	337	239	306	2677	680
85	3311	310	215	284	2717	689
86	3303	301	199	244	2758	697
87	3298	282	173	218	2798	702
88	3289	266	176	201	2822	711
89	3284	245	156	190	2849	716
90	3279	227	136	169	2883	721
91	3277	213	122	156	2908	723
92	3271	202	113	137	2932	729
93	3267	196	105	129	2942	733
94	3262	191	94	115	2956	738
95	3260	183	89	106	2971	740
96	3256	170	77	98	2988	744
97	3254	161	73	89	3004	746
98	3248	153	62	78	3017	752
99	3246	148	56	69	3029	754
100	3246	143	54	66	3037	754
101	3244	140	52	62	3042	756
102	3242	134	48	60	3048	758
103	3239	130	43	55	3054	761
104	3236	126	37	47	3063	764
105	3234	124	39	39	3071	766
106	3233	122	37	33	3078	767
107	3232	119	31	31	3082	768
108	3232	117	32	30	3085	768
109	3229	113	28	27	3089	771
110	3229	109	24	28	3092	771

Day	Population	Susceptible	Exposed	Infected	Recovered	Dead
111	3229	107	24	25	3097	771
112	3229	105	19	23	3101	771
113	3229	102	18	23	3104	771
114	3229	100	17	24	3105	771
115	3229	97	14	25	3107	771
116	3229	94	14	25	3110	771
117	3228	93	16	23	3112	772
118	3227	92	16	20	3115	773
119	3227	89	12	21	3117	773
120	3225	89	12	16	3120	775
121	3224	89	12	13	3122	776
122	3224	88	12	11	3125	776
123	3224	87	10	10	3127	776
124	3224	86	10	10	3128	776
125	3224	84	9	9	3131	776
126	3224	82	4	9	3133	776
127	3224	82	4	9	3133	776
128	3224	81	2	10	3133	776
129	3224	81	2	8	3135	776
130	3224	81	2	8	3135	776
131	3223	81	4	7	3135	777
132	3222	81	4	5	3136	778
133	3222	81	4	5	3136	778
134	3221	80	3	4	3137	779
135	3221	80	3	3	3138	779
136	3221	80	3	2	3139	779
137	3221	80	2	2	3139	779
138	3221	80	2	1	3140	779
139	3221	80	2	1	3140	779
140	3221	79	1	2	3140	779

Day	**Population**	**Susceptible**	**Exposed**	**Infected**	**Recovered**	**Dead**
141	3221	79	1	2	3140	779
142	3221	79	1	2	3140	779
143	3221	79	0	1	3141	779
144	3221	79	0	1	3141	779
145	3221	79	0	1	3141	779
146	3221	79	0	1	3141	779
147	3221	79	0	0	3142	779

Table G.3: Run 03: Time series table of the total number of population, susceptible, exposed, infected, recovered, and dead agents from day 1, the start of execution to day 147, when the number of exposed and infected agents became 0.

Day	**Population**	**Susceptible**	**Exposed**	**Infected**	**Recovered**	**Dead**
1	4000	3995	0	5	0	0
2	4000	3995	2	5	0	0
3	4000	3995	2	5	0	0
4	4000	3995	3	5	0	0
5	4000	3995	7	5	0	0
6	4000	3995	11	5	0	0
7	4000	3995	12	5	0	0
8	4000	3995	13	3	2	0
9	4000	3994	12	2	4	0
10	4000	3994	13	1	5	0
11	4000	3992	11	3	5	0
12	4000	3991	9	4	5	0
13	4000	3990	10	5	5	0
14	4000	3987	9	8	5	0
15	4000	3987	12	8	5	0
16	4000	3987	11	8	5	0
17	4000	3986	14	8	6	0
18	3999	3985	17	8	6	1
19	3999	3985	18	7	7	1
20	3999	3984	28	6	9	1

Day	**Population**	**Susceptible**	**Exposed**	**Infected**	**Recovered**	**Dead**
21	3999	3982	32	6	11	1
22	3999	3981	37	7	11	1
23	3999	3980	39	7	12	1
24	3999	3980	43	7	12	1
25	3999	3977	48	10	12	1
26	3999	3974	53	13	12	1
27	3999	3971	65	14	14	1
28	3999	3968	77	16	15	1
29	3999	3965	92	19	15	1
30	3999	3961	114	21	17	1
31	3999	3960	139	21	18	1
32	3999	3957	175	24	18	1
33	3999	3952	211	28	19	1
34	3999	3946	254	30	23	1
35	3998	3938	334	35	25	2
36	3997	3928	410	41	28	3
37	3996	3908	568	59	29	4
38	3995	3892	748	70	33	5
39	3995	3875	990	86	34	5
40	3995	3842	1323	118	35	5
41	3994	3805	1696	153	36	6
42	3994	3770	2012	182	42	6
43	3992	3717	2329	225	50	8
44	3990	3641	2690	287	62	10
45	3989	3538	2893	377	74	11
46	3985	3389	3002	509	87	15
47	3977	3211	2960	660	106	23
48	3974	3009	2811	842	123	26
49	3966	2809	2598	1014	143	34
50	3959	2591	2402	1191	177	41

Day	Population	Susceptible	Exposed	Infected	Recovered	Dead
51	3951	2385	2212	1344	222	49
52	3940	2155	1987	1521	264	60
53	3919	1947	1808	1635	337	81
54	3894	1781	1649	1666	447	106
55	3859	1628	1490	1650	581	141
56	3828	1502	1373	1584	742	172
57	3793	1370	1242	1518	905	207
58	3744	1257	1146	1423	1064	256
59	3692	1160	1049	1292	1240	308
60	3661	1052	935	1208	1401	339
61	3616	960	829	1100	1556	384
62	3570	884	747	956	1730	430
63	3544	802	664	892	1850	456
64	3523	741	618	833	1949	477
65	3494	687	581	756	2051	506
66	3467	632	518	673	2162	533
67	3441	581	480	620	2240	559
68	3419	531	421	572	2316	581
69	3408	497	384	511	2400	592
70	3394	461	348	464	2469	606
71	3381	434	316	413	2534	619
72	3368	394	286	373	2601	632
73	3359	364	264	348	2647	641
74	3347	342	229	315	2690	653
75	3339	324	215	286	2729	661
76	3331	311	202	248	2772	669
77	3315	297	195	217	2801	685
78	3305	281	181	191	2833	695
79	3298	268	167	179	2851	702
80	3290	256	147	152	2882	710

Day	Population	Susceptible	Exposed	Infected	Recovered	Dead
81	3285	244	134	140	2901	715
82	3280	235	124	121	2924	720
83	3276	224	118	111	2941	724
84	3272	214	110	107	2951	728
85	3270	201	87	103	2966	730
86	3268	195	78	90	2983	732
87	3265	191	73	80	2994	735
88	3265	186	71	76	3003	735
89	3260	176	68	72	3012	740
90	3257	173	65	64	3020	743
91	3252	166	60	60	3026	748
92	3250	159	48	58	3033	750
93	3249	152	44	57	3040	751
94	3249	149	43	56	3044	751
95	3247	148	44	46	3053	753
96	3246	146	46	40	3060	754
97	3244	143	46	37	3064	756
98	3244	139	49	34	3071	756
99	3243	132	40	34	3077	757
100	3241	131	40	30	3080	759
101	3240	128	37	29	3083	760
102	3240	124	32	26	3090	760
103	3240	122	30	27	3091	760
104	3239	119	29	28	3092	761
105	3239	118	30	27	3094	761
106	3239	115	25	27	3097	761
107	3238	114	23	22	3102	762
108	3237	111	21	22	3104	763
109	3237	108	19	22	3107	763
110	3236	108	17	17	3111	764

Day	Population	Susceptible	Exposed	Infected	Recovered	Dead
111	3236	107	14	17	3112	764
112	3236	103	12	17	3116	764
113	3236	103	11	16	3117	764
114	3235	102	10	15	3118	765
115	3235	102	11	13	3120	765
116	3233	102	11	10	3121	767
117	3233	102	10	9	3122	767
118	3233	102	8	6	3125	767
119	3233	101	7	4	3128	767
120	3233	101	7	4	3128	767
121	3232	99	5	5	3128	768
122	3232	97	5	6	3129	768
123	3232	97	5	6	3129	768
124	3232	96	4	6	3130	768
125	3232	96	3	6	3130	768
126	3232	96	4	6	3130	768
127	3232	96	4	5	3131	768
128	3232	96	5	5	3131	768
129	3231	96	5	4	3131	769
130	3231	96	5	2	3133	769
131	3231	95	5	2	3134	769
132	3231	94	4	3	3134	769
133	3231	94	4	3	3134	769
134	3231	94	4	2	3135	769
135	3231	94	3	2	3135	769
136	3231	94	3	2	3135	769
137	3231	94	3	2	3135	769
138	3231	93	3	3	3135	769
139	3231	93	3	2	3136	769
140	3231	92	2	3	3136	769

Day	Population	Susceptible	Exposed	Infected	Recovered	Dead
141	3230	92	1	2	3136	770
142	3230	92	1	2	3136	770
143	3230	92	1	2	3136	770
144	3230	91	0	3	3136	770
145	3230	91	0	3	3136	770
146	3230	91	0	3	3136	770
147	3230	91	0	3	3136	770
148	3230	91	0	1	3138	770
149	3230	91	0	1	3138	770
150	3230	91	0	1	3138	770
151	3230	91	0	1	3138	770
152	3229	91	0	0	3138	771

Table G.4: Run 04: Time series table of the total number of population, susceptible, exposed, infected, recovered, and dead agents from day 1, the start of execution to day 152, when the number of exposed and infected agents became 0.

Day	**Population**	**Susceptible**	**Exposed**	**Infected**	**Recovered**	**Dead**
1	4000	3995	1	5	0	0
2	4000	3995	4	5	0	0
3	4000	3995	7	5	0	0
4	4000	3995	9	5	0	0
5	4000	3995	13	5	0	0
6	4000	3995	15	5	0	0
7	4000	3995	18	5	0	0
8	4000	3995	16	5	0	0
9	4000	3994	16	3	3	0
10	3998	3994	16	1	3	2
11	3998	3992	13	3	3	2
12	3998	3990	11	5	3	2
13	3998	3988	10	7	3	2
14	3998	3986	8	9	3	2
15	3998	3986	14	9	3	2
16	3998	3986	15	8	4	2
17	3998	3984	15	10	4	2
18	3998	3983	20	10	5	2
19	3998	3982	22	11	5	2
20	3998	3982	22	9	7	2

Day	**Population**	**Susceptible**	**Exposed**	**Infected**	**Recovered**	**Dead**
21	3998	3982	29	7	9	2
22	3998	3982	31	6	10	2
23	3998	3978	33	9	11	2
24	3998	3975	43	10	13	2
25	3998	3973	52	12	13	2
26	3998	3970	79	14	14	2
27	3997	3969	82	13	15	3
28	3997	3968	88	14	15	3
29	3997	3963	115	19	15	3
30	3997	3961	134	19	17	3
31	3997	3958	170	22	17	3
32	3996	3948	241	27	21	4
33	3996	3940	302	32	24	4
34	3996	3930	396	42	24	4
35	3996	3918	473	52	26	4
36	3995	3914	609	55	26	5
37	3995	3897	762	69	29	5
38	3995	3870	979	92	33	5
39	3995	3836	1279	124	35	5
40	3995	3810	1622	144	41	5
41	3994	3752	1994	195	47	6
42	3993	3691	2440	243	59	7
43	3991	3614	2758	310	67	9
44	3988	3512	2973	402	74	12
45	3982	3413	3020	488	81	18
46	3978	3253	2960	626	99	22
47	3976	3055	2827	795	126	24
48	3973	2816	2611	1007	150	27
49	3953	2574	2379	1195	184	47
50	3937	2321	2150	1388	228	63

Day	**Population**	**Susceptible**	**Exposed**	**Infected**	**Recovered**	**Dead**
51	3928	2114	1936	1516	298	72
52	3910	1932	1766	1627	351	90
53	3887	1775	1637	1671	441	113
54	3858	1618	1482	1708	532	142
55	3817	1494	1361	1641	682	183
56	3772	1370	1253	1565	837	228
57	3717	1270	1155	1425	1022	283
58	3665	1174	1049	1264	1227	335
59	3616	1072	944	1138	1406	384
60	3589	981	834	1050	1558	411
61	3556	909	765	927	1720	444
62	3527	836	706	865	1826	473
63	3497	774	656	774	1949	503
64	3452	709	590	707	2036	548
65	3423	661	549	645	2117	577
66	3400	619	511	593	2188	600
67	3382	574	475	541	2267	618
68	3364	517	418	493	2354	636
69	3345	484	385	451	2410	655
70	3328	452	341	411	2465	672
71	3315	423	313	364	2528	685
72	3300	395	287	335	2570	700
73	3289	368	258	315	2606	711
74	3285	348	235	288	2649	715
75	3279	328	212	255	2696	721
76	3270	303	195	231	2736	730
77	3262	283	176	213	2766	738
78	3258	271	167	203	2784	742
79	3254	254	152	183	2817	746
80	3247	239	146	164	2844	753

Day	Population	Susceptible	Exposed	Infected	Recovered	Dead
81	3244	232	142	146	2866	756
82	3239	218	129	133	2888	761
83	3231	206	118	123	2902	769
84	3227	192	99	120	2915	773
85	3220	182	87	110	2928	780
86	3219	172	79	105	2942	781
87	3218	167	71	95	2956	782
88	3215	160	70	82	2973	785
89	3210	155	68	77	2978	790
90	3206	150	68	72	2984	794
91	3204	145	62	69	2990	796
92	3196	140	58	56	3000	804
93	3193	135	51	50	3008	807
94	3188	129	40	44	3015	812
95	3185	125	39	42	3018	815
96	3184	122	32	41	3021	816
97	3183	119	27	36	3028	817
98	3182	119	25	33	3030	818
99	3180	113	18	35	3032	820
100	3180	110	15	31	3039	820
101	3178	107	16	28	3043	822
102	3178	106	14	25	3047	822
103	3178	106	13	22	3050	822
104	3177	103	13	21	3053	823
105	3177	103	15	17	3057	823
106	3177	101	12	17	3059	823
107	3177	99	10	18	3060	823
108	3176	99	10	14	3063	824
109	3174	99	11	10	3065	826
110	3174	99	11	9	3066	826

Day	**Population**	**Susceptible**	**Exposed**	**Infected**	**Recovered**	**Dead**
111	3173	97	9	9	3067	827
112	3173	96	8	9	3068	827
113	3173	96	7	7	3070	827
114	3172	96	9	6	3070	828
115	3172	96	8	5	3071	828
116	3172	95	7	4	3073	828
117	3172	95	7	4	3073	828
118	3172	95	8	3	3074	828
119	3171	95	7	2	3074	829
120	3170	94	6	2	3074	830
121	3170	92	4	4	3074	830
122	3170	91	4	5	3074	830
123	3170	91	3	5	3074	830
124	3170	90	3	6	3074	830
125	3170	90	3	6	3074	830
126	3170	90	3	5	3075	830
127	3170	90	2	4	3076	830
128	3170	90	2	4	3076	830
129	3170	90	2	4	3076	830
130	3170	90	2	4	3076	830
131	3169	90	2	1	3078	831
132	3169	89	2	2	3078	831
133	3169	89	2	1	3079	831
134	3169	89	2	1	3079	831
135	3169	89	2	1	3079	831
136	3169	89	2	1	3079	831
137	3169	89	2	1	3079	831
138	3169	88	1	2	3079	831
139	3169	88	1	2	3079	831
140	3169	87	0	3	3079	831

Day	**Population**	**Susceptible**	**Exposed**	**Infected**	**Recovered**	**Dead**
141	3169	87	0	2	3080	831
142	3169	87	0	2	3080	831
143	3169	87	0	2	3080	831
144	3169	87	0	2	3080	831
145	3169	87	0	2	3080	831
146	3169	87	0	1	3081	831
147	3169	87	0	1	3081	831

Table G.5: Run 05: Time series table of the total number of population, susceptible, exposed, infected, recovered, and dead agents from day 1, the start of execution to day 147, when the number of exposed and infected agents became 0.

Appendix H

Figures for Scenario 03

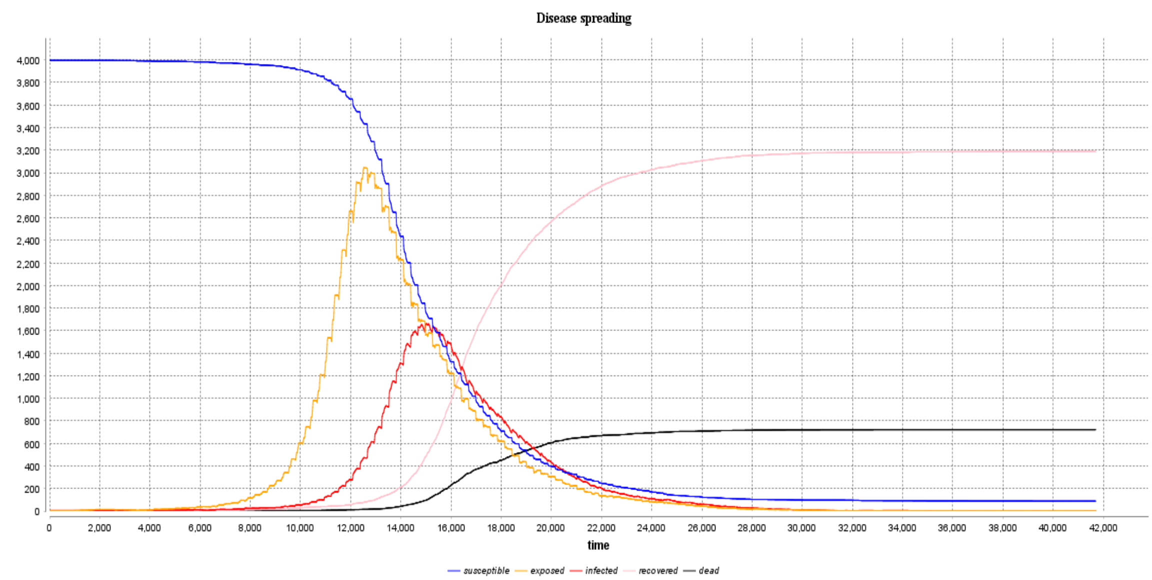

Figure H.1: Time Series chart of Scenario 03 Run 01.

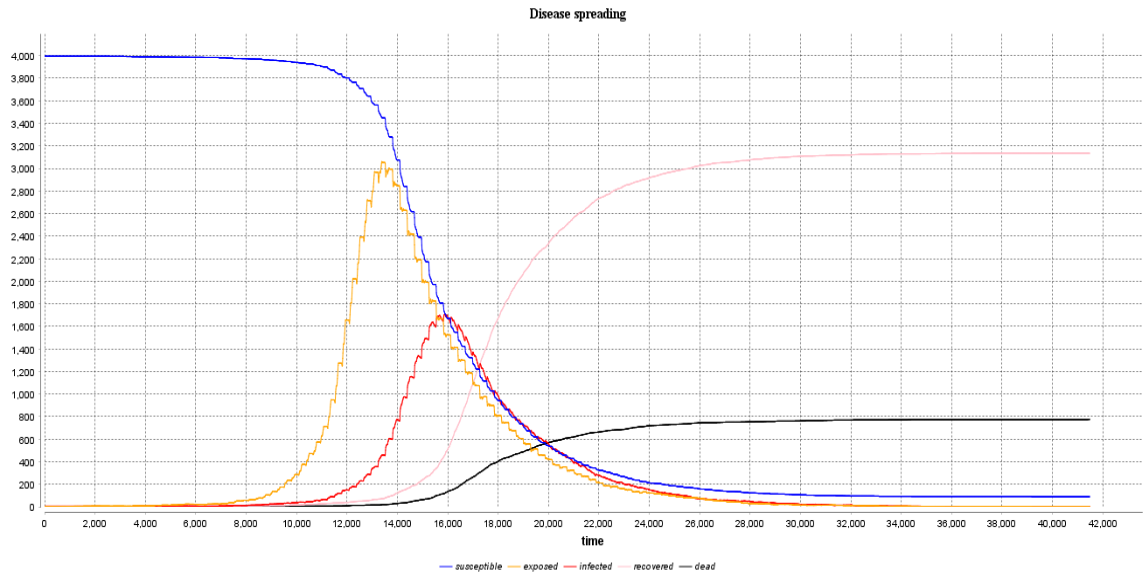

Figure H.2: Time Series chart of Scenario 03 Run 02.

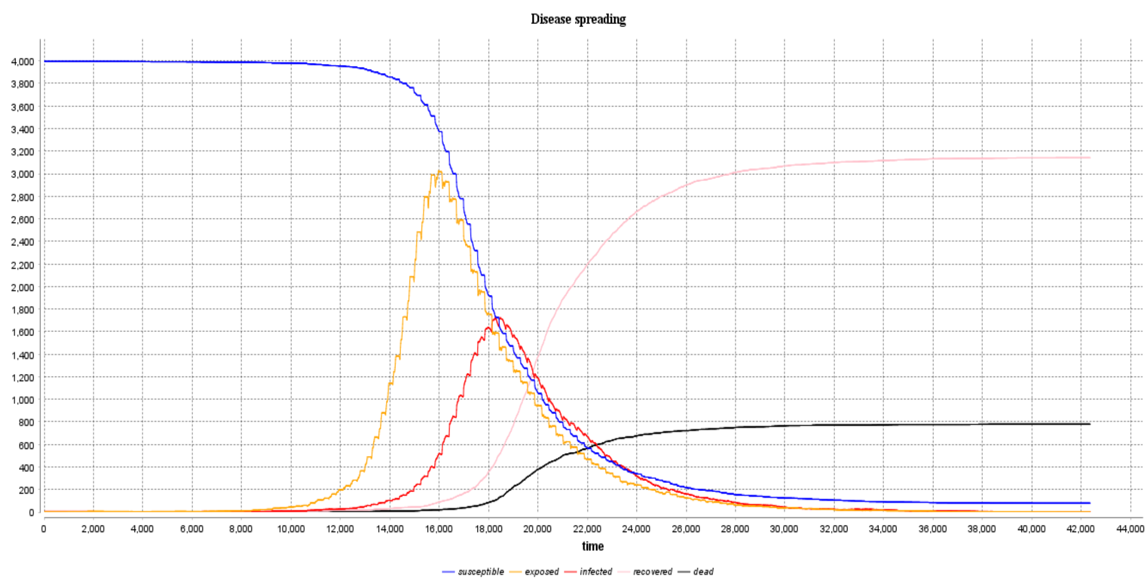

Figure H.3: Time Series chart of Scenario 03 Run 03.

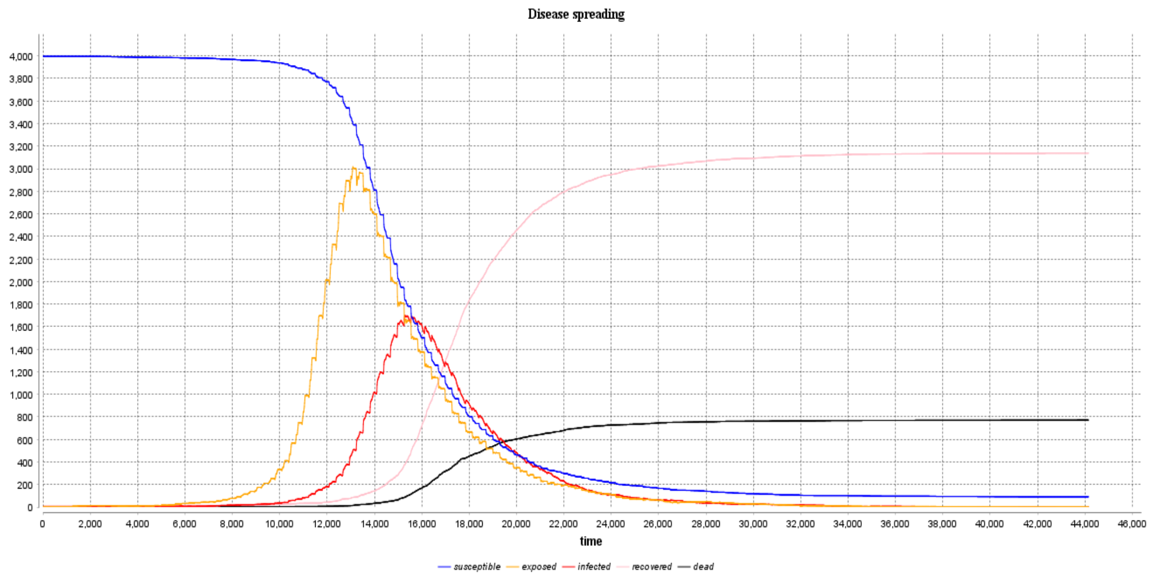

Figure H.4: Time Series chart of Scenario 03 Run 04.

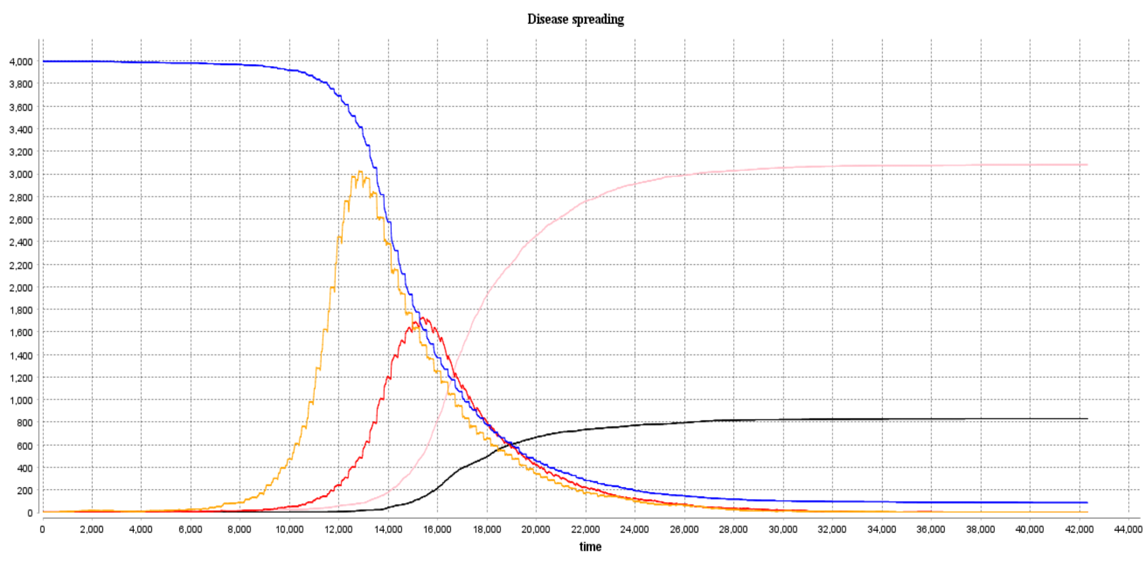

Figure H.5: Time Series chart of Scenario 03 Run 05.

Appendix I

Table for Scenario 04

Day	Population	Susceptible	Exposed	Infected	Recovered	Dead
1	4000	3995	0	5	0	0
2	4000	3995	2	5	0	0
3	4000	3995	3	5	0	0
4	4000	3995	5	5	0	0
5	4000	3995	11	5	0	0
6	4000	3995	14	5	0	0
7	4000	3995	14	5	0	0
8	4000	3994	13	5	1	0
9	3999	3994	12	3	2	1
10	3999	3993	10	2	4	1
11	3999	3993	13	2	4	1
12	3999	3991	11	4	4	1
13	3999	3991	12	4	4	1
14	3999	3991	11	4	4	1
15	3999	3990	10	5	4	1
16	3999	3990	10	4	5	1
17	3999	3990	8	4	5	1
18	3999	3989	6	4	6	1
19	3999	3989	6	4	6	1
20	3999	3988	7	5	6	1

Day	**Population**	**Susceptible**	**Exposed**	**Infected**	**Recovered**	**Dead**
21	3999	3988	7	4	7	1
22	3999	3986	8	5	8	1
23	3999	3985	11	6	8	1
24	3999	3985	12	5	9	1
25	3999	3985	13	5	9	1
26	3999	3983	16	7	9	1
27	3999	3983	18	6	10	1
28	3999	3982	16	7	10	1
29	3999	3980	23	8	11	1
30	3999	3980	27	7	12	1
31	3998	3979	31	6	13	2
32	3998	3978	33	7	13	2
33	3998	3977	33	8	13	2
34	3998	3977	40	7	14	2
35	3997	3976	42	7	14	3
36	3997	3975	40	7	15	3
37	3997	3969	40	13	15	3
38	3997	3967	39	13	17	3
39	3997	3962	49	18	17	3
40	3997	3957	48	22	18	3
41	3996	3954	61	24	18	4
42	3996	3953	60	25	18	4
43	3996	3953	59	23	20	4
44	3995	3946	59	28	21	5
45	3995	3941	57	31	23	5
46	3995	3934	59	34	27	5
47	3995	3927	61	36	32	5
48	3995	3924	62	35	36	5
49	3995	3920	57	35	40	5
50	3995	3919	53	35	41	5

Day	Population	Susceptible	Exposed	Infected	Recovered	Dead
51	3995	3916	78	34	45	5
52	3995	3912	117	36	47	5
53	3993	3905	154	36	52	7
54	3993	3902	187	34	57	7
55	3992	3898	250	33	61	8
56	3989	3897	308	29	63	11
57	3987	3885	366	38	64	13
58	3987	3875	458	44	68	13
59	3987	3858	550	60	69	13
60	3986	3837	740	75	74	14
61	3985	3816	985	88	81	15
62	3984	3785	1281	116	83	16
63	3984	3761	1583	139	84	16
64	3984	3719	1913	177	88	16
65	3983	3670	2275	218	95	17
66	3981	3598	2590	280	103	19
67	3981	3494	2491	372	115	19
68	3978	3361	2348	485	132	22
69	3975	3181	2129	644	150	25
70	3971	3002	1934	798	171	29
71	3963	2815	1642	957	191	37
72	3949	2594	1433	1142	213	51
73	3935	2398	1182	1291	246	65
74	3920	2230	980	1386	304	80
75	3901	2125	847	1406	370	99
76	3871	2053	754	1348	470	129
77	3839	1993	696	1270	576	161
78	3807	1941	621	1152	714	193
79	3766	1879	549	1019	868	234
80	3727	1823	485	864	1040	273

Day	Population	Susceptible	Exposed	Infected	Recovered	Dead
81	3695	1764	795	714	1217	305
82	3656	1700	1050	614	1342	344
83	3632	1667	1223	526	1439	368
84	3611	1633	1308	470	1508	389
85	3595	1599	1351	429	1567	405
86	3581	1571	1376	395	1615	419
87	3572	1499	1334	417	1656	428
88	3556	1396	1225	444	1716	444
89	3544	1287	1108	500	1757	456
90	3533	1150	964	583	1800	467
91	3519	1024	838	660	1835	481
92	3509	936	762	706	1867	491
93	3497	869	719	733	1895	503
94	3487	819	692	754	1914	513
95	3475	779	668	743	1953	525
96	3466	739	632	703	2024	534
97	3447	683	542	648	2116	553
98	3423	638	463	573	2212	577
99	3402	580	372	507	2315	598
100	3381	528	284	455	2398	619
101	3367	480	214	422	2465	633
102	3358	447	169	395	2516	642
103	3350	415	116	386	2549	650
104	3339	393	80	356	2590	661
105	3328	376	55	326	2626	672
106	3317	369	41	287	2661	683
107	3309	364	36	238	2707	691
108	3297	360	31	185	2752	703
109	3289	359	24	141	2789	711
110	3282	357	18	108	2817	718

Day	**Population**	**Susceptible**	**Exposed**	**Infected**	**Recovered**	**Dead**
111	3274	356	23	76	2842	726
112	3270	351	21	53	2866	730
113	3265	350	22	32	2883	735
114	3263	349	24	23	2891	737
115	3263	349	23	18	2896	737
116	3263	349	28	12	2902	737
117	3263	346	23	13	2904	737
118	3263	345	26	12	2906	737
119	3262	343	25	11	2908	738
120	3261	339	24	14	2908	739
121	3261	335	19	16	2910	739
122	3261	334	18	16	2911	739
123	3261	334	18	16	2911	739
124	3261	333	17	15	2913	739
125	3260	331	16	16	2913	740
126	3260	330	17	17	2913	740
127	3260	330	14	14	2916	740
128	3260	328	12	14	2918	740
129	3259	326	10	13	2920	741
130	3259	324	9	12	2923	741
131	3259	324	9	10	2925	741
132	3259	323	7	9	2927	741
133	3259	323	6	8	2928	741
134	3259	321	4	10	2928	741
135	3259	320	3	10	2929	741
136	3259	320	2	10	2929	741
137	3257	320	1	8	2929	743
138	3256	320	1	5	2931	744
139	3256	320	1	4	2932	744
140	3256	320	1	3	2933	744

Day	**Population**	**Susceptible**	**Exposed**	**Infected**	**Recovered**	**Dead**
141	3256	319	0	4	2933	744
142	3256	319	0	3	2934	744
143	3256	319	0	3	2934	744
144	3256	319	1	1	2936	744
145	3256	319	1	1	2936	744
146	3256	319	1	1	2936	744
147	3256	319	1	1	2936	744
148	3256	319	1	1	2936	744
149	3256	319	2	0	2937	744
150	3256	319	2	0	2937	744
151	3256	319	2	0	2937	744
152	3256	319	2	0	2937	744
153	3256	318	1	1	2937	744
154	3256	318	1	1	2937	744
155	3256	318	1	1	2937	744
156	3256	318	0	1	2937	744
157	3256	318	0	1	2937	744
158	3256	318	0	1	2937	744
159	3256	318	0	1	2937	744
160	3256	318	0	0	2938	744

Table I.1: Run 01: Time series table of the total number of population, susceptible, exposed, infected, recovered, and dead agents from day 1, the start of execution to day 160, when the number of exposed and infected agents became 0.

Day	**Population**	**Susceptible**	**Exposed**	**Infected**	**Recovered**	**Dead**
1	4000	3995	1	5	0	0
2	4000	3995	2	5	0	0
3	4000	3995	2	5	0	0
4	4000	3995	3	5	0	0
5	4000	3995	5	5	0	0
6	4000	3995	8	5	0	0
7	4000	3995	8	5	0	0
8	3998	3995	8	3	0	2
9	3998	3994	7	2	2	2
10	3998	3994	7	1	3	2
11	3998	3993	6	2	3	2
12	3998	3992	4	3	3	2
13	3998	3991	10	4	3	2
14	3998	3990	13	5	3	2
15	3998	3990	12	5	3	2
16	3998	3990	12	4	4	2
17	3998	3990	12	4	4	2
18	3997	3989	11	4	4	3
19	3997	3986	12	7	4	3
20	3997	3985	11	8	4	3

Day	**Population**	**Susceptible**	**Exposed**	**Infected**	**Recovered**	**Dead**
21	3997	3984	11	8	5	3
22	3997	3983	9	8	6	3
23	3997	3982	12	8	7	3
24	3997	3982	11	8	7	3
25	3997	3982	10	8	7	3
26	3997	3982	12	8	7	3
27	3997	3981	13	8	8	3
28	3997	3980	14	6	11	3
29	3996	3978	16	7	11	4
30	3996	3977	17	7	12	4
31	3996	3977	19	6	13	4
32	3996	3977	24	6	13	4
33	3996	3977	26	5	14	4
34	3996	3975	31	7	14	4
35	3996	3974	38	6	16	4
36	3995	3973	41	6	16	5
37	3995	3972	41	7	16	5
38	3995	3966	66	12	17	5
39	3995	3965	69	13	17	5
40	3995	3962	78	15	18	5
41	3995	3959	96	17	19	5
42	3995	3954	98	22	19	5
43	3995	3950	90	26	19	5
44	3995	3947	94	28	20	5
45	3995	3943	96	31	21	5
46	3993	3933	89	38	22	7
47	3992	3925	96	41	26	8
48	3991	3918	89	46	27	9
49	3989	3915	90	45	29	11
50	3988	3904	83	52	32	12

Day	**Population**	**Susceptible**	**Exposed**	**Infected**	**Recovered**	**Dead**
51	3988	3896	149	55	37	12
52	3988	3894	199	54	40	12
53	3985	3889	258	54	42	15
54	3983	3885	329	53	45	17
55	3981	3878	413	50	53	19
56	3979	3868	523	51	60	21
57	3978	3849	674	66	63	22
58	3976	3834	851	75	67	24
59	3974	3808	1076	94	72	26
60	3972	3778	1381	115	79	28
61	3972	3730	1762	160	82	28
62	3972	3680	2144	208	84	28
63	3970	3619	2516	262	89	30
64	3968	3538	2791	331	99	32
65	3966	3433	2957	424	109	34
66	3959	3299	2975	537	123	41
67	3956	3150	2748	667	139	44
68	3950	2938	2424	847	165	50
69	3944	2690	2096	1062	192	56
70	3932	2453	1727	1247	232	68
71	3922	2210	1371	1432	280	78
72	3906	2008	1079	1563	335	94
73	3887	1871	887	1610	406	113
74	3860	1746	714	1608	506	140
75	3829	1672	628	1530	627	171
76	3787	1604	546	1409	774	213
77	3737	1558	493	1240	939	263
78	3677	1520	446	1041	1116	323
79	3631	1470	385	852	1309	369
80	3592	1424	318	687	1481	408

Day	**Population**	**Susceptible**	**Exposed**	**Infected**	**Recovered**	**Dead**
81	3565	1390	487	556	1619	435
82	3537	1352	616	456	1729	463
83	3514	1323	738	388	1803	486
84	3498	1312	835	322	1864	502
85	3487	1300	887	282	1905	513
86	3479	1283	921	256	1940	521
87	3469	1241	917	249	1979	531
88	3463	1180	893	267	2016	537
89	3454	1115	850	292	2047	546
90	3447	1045	811	333	2069	553
91	3437	950	747	395	2092	563
92	3432	873	691	444	2115	568
93	3430	824	650	482	2124	570
94	3427	780	642	507	2140	573
95	3421	736	608	520	2165	579
96	3413	686	572	515	2212	587
97	3399	639	479	499	2261	601
98	3388	593	395	475	2320	612
99	3368	548	310	443	2377	632
100	3346	501	238	408	2437	654
101	3339	463	168	389	2487	661
102	3328	431	124	366	2531	672
103	3316	405	83	350	2561	684
104	3307	391	58	319	2597	693
105	3302	376	36	282	2644	698
106	3297	371	29	244	2682	703
107	3287	368	26	203	2716	713
108	3276	367	23	152	2757	724
109	3268	366	20	113	2789	732
110	3266	365	18	78	2823	734

Day	**Population**	**Susceptible**	**Exposed**	**Infected**	**Recovered**	**Dead**
111	3261	361	16	65	2835	739
112	3259	361	21	42	2856	741
113	3258	360	21	28	2870	742
114	3256	360	20	16	2880	744
115	3256	360	20	10	2886	744
116	3256	357	16	11	2888	744
117	3255	357	19	9	2889	745
118	3255	354	17	11	2890	745
119	3255	351	19	13	2891	745
120	3254	351	17	9	2894	746
121	3254	351	17	9	2894	746
122	3254	350	15	10	2894	746
123	3254	350	18	8	2896	746
124	3254	349	18	9	2896	746
125	3254	349	16	8	2897	746
126	3254	346	12	9	2899	746
127	3253	346	10	6	2901	747
128	3253	345	9	7	2901	747
129	3253	345	7	6	2902	747
130	3253	344	4	7	2902	747
131	3253	344	3	7	2902	747
132	3253	343	0	6	2904	747
133	3253	343	0	5	2905	747
134	3253	343	0	4	2906	747
135	3253	343	0	4	2906	747
136	3252	343	0	2	2907	748
137	3252	343	0	2	2907	748
138	3252	343	0	1	2908	748
139	3252	343	0	1	2908	748
140	3252	343	0	1	2908	748

Day	Population	Susceptible	Exposed	Infected	Recovered	Dead
141	3252	343	0	0	2908	749

Table I.2: Run 02: Time series table of the total number of population, susceptible, exposed, infected, recovered, and dead agents from day 1, the start of execution to day 141, when the number of exposed and infected agents became 0.

Day	**Population**	**Susceptible**	**Exposed**	**Infected**	**Recovered**	**Dead**
1	4000	3995	1	5	0	0
2	4000	3995	1	5	0	0
3	4000	3995	1	5	0	0
4	4000	3995	6	5	0	0
5	4000	3995	8	5	0	0
6	4000	3995	10	5	0	0
7	4000	3995	10	5	0	0
8	4000	3995	10	3	2	0
9	4000	3995	10	1	4	0
10	4000	3995	9	0	5	0
11	4000	3993	6	2	5	0
12	4000	3991	8	4	5	0
13	4000	3989	7	6	5	0
14	4000	3989	8	6	5	0
15	4000	3989	8	6	5	0
16	4000	3989	8	6	5	0
17	4000	3989	8	6	5	0
18	4000	3989	7	6	5	0
19	4000	3988	10	7	5	0
20	4000	3987	9	6	7	0

Day	Population	Susceptible	Exposed	Infected	Recovered	Dead
21	3999	3986	9	4	9	1
22	3999	3985	8	5	9	1
23	3999	3985	9	4	10	1
24	3999	3985	9	4	10	1
25	3999	3984	8	5	10	1
26	3999	3983	12	6	10	1
27	3999	3982	12	7	10	1
28	3999	3980	15	8	11	1
29	3998	3979	19	8	11	2
30	3998	3979	22	8	11	2
31	3998	3978	26	8	12	2
32	3998	3978	26	7	13	2
33	3998	3976	26	9	13	2
34	3997	3975	29	9	13	3
35	3996	3973	36	9	14	4
36	3996	3971	44	9	16	4
37	3996	3967	70	13	16	4
38	3995	3966	68	13	16	5
39	3995	3962	62	17	16	5
40	3995	3960	72	19	16	5
41	3995	3957	68	20	18	5
42	3994	3955	67	19	20	6
43	3994	3951	65	23	20	6
44	3994	3944	66	27	23	6
45	3994	3935	66	35	24	6
46	3994	3928	74	40	26	6
47	3994	3926	82	38	30	6
48	3994	3921	78	40	33	6
49	3994	3917	78	41	36	6
50	3994	3915	79	40	39	6

Day	**Population**	**Susceptible**	**Exposed**	**Infected**	**Recovered**	**Dead**
51	3993	3910	102	42	41	7
52	3992	3903	149	44	45	8
53	3989	3897	207	41	51	11
54	3988	3891	262	41	56	12
55	3985	3887	329	41	57	15
56	3985	3879	406	46	60	15
57	3985	3874	499	48	63	15
58	3981	3859	606	56	66	19
59	3978	3839	819	70	69	22
60	3978	3811	1054	94	73	22
61	3976	3778	1364	121	77	24
62	3976	3743	1725	151	82	24
63	3976	3696	2116	191	89	24
64	3974	3647	2431	232	95	26
65	3972	3569	2722	304	99	28
66	3971	3442	2940	424	105	29
67	3964	3312	2766	534	118	36
68	3960	3142	2524	682	136	40
69	3954	2937	2244	854	163	46
70	3948	2702	1925	1056	190	52
71	3939	2485	1599	1235	219	61
72	3929	2253	1287	1410	266	71
73	3909	2061	1042	1531	317	91
74	3889	1913	842	1588	388	111
75	3864	1803	694	1579	482	136
76	3829	1730	615	1478	621	171
77	3792	1693	574	1297	802	208
78	3748	1640	499	1144	964	252
79	3710	1598	455	983	1129	290
80	3668	1548	388	799	1321	332

Day	**Population**	**Susceptible**	**Exposed**	**Infected**	**Recovered**	**Dead**
81	3633	1505	565	644	1484	367
82	3601	1470	758	525	1606	399
83	3575	1445	893	414	1716	425
84	3567	1419	961	369	1779	433
85	3554	1400	1041	317	1837	446
86	3548	1366	1083	309	1873	452
87	3538	1327	1089	298	1913	462
88	3529	1260	1041	313	1956	471
89	3521	1175	951	352	1994	479
90	3514	1061	847	432	2021	486
91	3505	965	768	491	2049	495
92	3497	900	720	526	2071	503
93	3493	841	679	563	2089	507
94	3488	793	659	583	2112	512
95	3482	735	619	606	2141	518
96	3468	688	584	595	2185	532
97	3448	639	508	575	2234	552
98	3425	593	432	521	2311	575
99	3410	542	344	487	2381	590
100	3395	498	272	443	2454	605
101	3379	461	203	412	2506	621
102	3366	421	142	389	2556	634
103	3352	391	97	368	2593	648
104	3346	377	67	338	2631	654
105	3336	357	45	306	2673	664
106	3329	348	34	263	2718	671
107	3319	347	31	213	2759	681
108	3310	345	24	170	2795	690
109	3299	342	21	139	2818	701
110	3286	339	17	102	2845	714

Day	Population	Susceptible	Exposed	Infected	Recovered	Dead
111	3279	336	19	64	2879	721
112	3274	334	15	45	2895	726
113	3269	329	12	35	2905	731
114	3269	329	14	26	2914	731
115	3268	329	14	21	2918	732
116	3268	329	14	16	2923	732
117	3268	328	13	15	2925	732
118	3266	328	12	11	2927	734
119	3266	328	13	10	2928	734
120	3266	328	14	9	2929	734
121	3265	327	12	4	2934	735
122	3265	327	11	3	2935	735
123	3265	326	8	3	2936	735
124	3265	326	7	3	2936	735
125	3265	326	6	3	2936	735
126	3265	326	5	2	2937	735
127	3265	325	6	3	2937	735
128	3265	325	5	3	2937	735
129	3265	323	4	4	2938	735
130	3265	323	5	4	2938	735
131	3265	323	5	4	2938	735
132	3265	323	5	3	2939	735
133	3265	322	4	4	2939	735
134	3265	321	3	5	2939	735
135	3264	321	3	4	2939	736
136	3264	321	2	3	2940	736
137	3264	320	1	3	2941	736
138	3264	320	1	3	2941	736
139	3264	320	1	3	2941	736
140	3264	320	0	3	2941	736

Day	**Population**	**Susceptible**	**Exposed**	**Infected**	**Recovered**	**Dead**
141	3264	320	0	3	2941	736
142	3264	320	0	3	2941	736
143	3263	320	0	1	2942	737
144	3263	320	0	1	2942	737
145	3263	320	0	0	2943	737

Table I.3: Run 03: Time series table of the total number of population, susceptible, exposed, infected, recovered, and dead agents from day 1, the start of execution to day 145, when the number of exposed and infected agents became 0.

Day	**Population**	**Susceptible**	**Exposed**	**Infected**	**Recovered**	**Dead**
1	4000	3995	0	5	0	0
2	4000	3995	1	5	0	0
3	4000	3995	4	5	0	0
4	4000	3995	5	5	0	0
5	4000	3995	7	5	0	0
6	4000	3995	10	5	0	0
7	4000	3995	10	5	0	0
8	4000	3994	13	6	0	0
9	4000	3994	13	5	1	0
10	4000	3993	13	5	2	0
11	3999	3993	17	2	4	1
12	3999	3990	19	5	4	1
13	3999	3988	18	7	4	1
14	3999	3987	18	8	4	1
15	3999	3985	17	10	4	1
16	3999	3985	17	10	4	1
17	3999	3984	18	11	4	1
18	3999	3981	15	13	5	1
19	3999	3980	16	14	5	1
20	3998	3980	15	11	7	2

Day	**Population**	**Susceptible**	**Exposed**	**Infected**	**Recovered**	**Dead**
21	3997	3978	12	10	9	3
22	3997	3976	12	11	10	3
23	3997	3974	10	12	11	3
24	3997	3974	15	11	12	3
25	3997	3974	15	11	12	3
26	3997	3974	20	9	14	3
27	3997	3972	27	8	17	3
28	3997	3972	28	8	17	3
29	3997	3971	30	8	18	3
30	3997	3971	31	6	20	3
31	3997	3968	40	7	22	3
32	3997	3965	47	10	22	3
33	3997	3963	50	11	23	3
34	3996	3962	58	11	23	4
35	3996	3960	70	13	23	4
36	3995	3958	80	13	24	5
37	3995	3950	103	21	24	5
38	3995	3944	106	26	25	5
39	3995	3943	106	25	27	5
40	3995	3941	103	25	29	5
41	3995	3930	108	33	32	5
42	3995	3922	113	40	33	5
43	3994	3914	122	46	34	6
44	3994	3906	127	49	39	6
45	3993	3896	127	54	43	7
46	3993	3891	125	57	45	7
47	3991	3888	123	54	49	9
48	3991	3878	126	62	51	9
49	3990	3867	132	69	54	10
50	3988	3858	130	71	59	12

Day	**Population**	**Susceptible**	**Exposed**	**Infected**	**Recovered**	**Dead**
51	3987	3853	203	68	66	13
52	3984	3845	312	62	77	16
53	3982	3841	429	58	83	18
54	3982	3830	536	64	88	18
55	3982	3824	670	64	94	18
56	3982	3811	834	74	97	18
57	3980	3793	1007	83	104	20
58	3977	3756	1369	109	112	23
59	3975	3711	1703	146	118	25
60	3974	3647	2061	199	128	26
61	3973	3576	2464	264	133	27
62	3970	3500	2768	333	137	30
63	3969	3399	2892	425	145	31
64	3966	3290	2918	522	154	34
65	3965	3131	2842	662	172	35
66	3958	2956	2737	802	200	42
67	3952	2725	2382	1008	219	48
68	3941	2492	2001	1194	255	59
69	3925	2260	1653	1353	312	75
70	3901	2054	1334	1476	371	99
71	3882	1861	1043	1575	446	118
72	3863	1714	833	1614	535	137
73	3838	1599	685	1589	650	162
74	3801	1512	565	1512	777	199
75	3764	1448	493	1388	928	236
76	3717	1401	434	1214	1102	283
77	3668	1361	385	1016	1291	332
78	3629	1332	344	829	1468	371
79	3595	1307	319	663	1625	405
80	3565	1274	265	526	1765	435

Day	Population	Susceptible	Exposed	Infected	Recovered	Dead
81	3532	1239	384	407	1886	468
82	3516	1207	490	346	1963	484
83	3499	1188	593	290	2021	501
84	3481	1164	677	252	2065	519
85	3474	1141	758	244	2089	526
86	3470	1128	797	218	2124	530
87	3463	1101	812	220	2142	537
88	3458	1047	795	240	2171	542
89	3451	982	756	276	2193	549
90	3447	910	718	316	2221	553
91	3442	835	634	363	2244	558
92	3436	784	603	387	2265	564
93	3433	725	542	425	2283	567
94	3430	676	513	455	2299	570
95	3426	641	480	467	2318	574
96	3417	603	466	459	2355	583
97	3408	564	396	445	2399	592
98	3387	528	320	406	2453	613
99	3370	490	254	370	2510	630
100	3361	452	197	360	2549	639
101	3353	422	146	331	2600	647
102	3346	397	112	306	2643	654
103	3339	374	77	286	2679	661
104	3329	368	59	248	2713	671
105	3317	361	37	213	2743	683
106	3310	357	29	181	2772	690
107	3303	355	24	147	2801	697
108	3297	350	18	119	2828	703
109	3290	349	13	87	2854	710
110	3289	349	11	59	2881	711

Day	**Population**	**Susceptible**	**Exposed**	**Infected**	**Recovered**	**Dead**
111	3286	348	17	42	2896	714
112	3283	346	19	30	2907	717
113	3281	346	20	23	2912	719
114	3280	345	20	16	2919	720
115	3280	344	21	12	2924	720
116	3279	344	23	9	2926	721
117	3278	342	23	7	2929	722
118	3278	339	21	10	2929	722
119	3278	336	17	12	2930	722
120	3278	334	12	13	2931	722
121	3277	333	10	13	2931	723
122	3277	332	11	12	2933	723
123	3277	332	10	12	2933	723
124	3277	331	9	13	2933	723
125	3277	331	10	13	2933	723
126	3277	331	11	11	2935	723
127	3276	330	9	7	2939	724
128	3275	330	9	6	2939	725
129	3275	330	9	3	2942	725
130	3275	328	6	5	2942	725
131	3275	327	4	6	2942	725
132	3275	327	3	5	2943	725
133	3275	326	2	6	2943	725
134	3275	326	2	5	2944	725
135	3275	324	0	7	2944	725
136	3275	324	0	6	2945	725
137	3275	324	0	6	2945	725
138	3275	324	0	5	2946	725
139	3275	324	0	4	2947	725
140	3274	324	0	3	2947	726

Day	**Population**	**Susceptible**	**Exposed**	**Infected**	**Recovered**	**Dead**
141	3274	324	1	3	2947	726
142	3274	324	1	3	2947	726
143	3274	324	3	2	2948	726
144	3274	324	3	0	2950	726
145	3274	324	3	0	2950	726
146	3274	324	3	0	2950	726
147	3274	323	3	1	2950	726
148	3274	323	3	1	2950	726
149	3274	322	2	2	2950	726
150	3274	321	2	3	2950	726
151	3274	321	2	3	2950	726
152	3274	321	2	3	2950	726
153	3274	321	2	3	2950	726
154	3274	321	2	2	2951	726
155	3274	321	2	2	2951	726
156	3274	320	1	3	2951	726
157	3273	319	1	3	2951	727
158	3273	319	1	2	2952	727
159	3273	319	1	2	2952	727
160	3273	319	1	2	2952	727
161	3273	319	1	2	2952	727
162	3273	319	1	2	2952	727
163	3273	319	1	2	2952	727
164	3273	319	1	1	2953	727
165	3273	319	1	1	2953	727
166	3273	319	0	0	2955	727

Table I.4: Run 04: Time series table of the total number of population, susceptible, exposed, infected, recovered, and dead agents from day 1, the start of execution to day 166, when the number of exposed and infected agents became 0.

Day	**Population**	**Susceptible**	**Exposed**	**Infected**	**Recovered**	**Dead**
1	4000	3995	1	5	0	0
2	4000	3995	2	5	0	0
3	4000	3995	5	5	0	0
4	4000	3995	7	5	0	0
5	4000	3995	13	5	0	0
6	4000	3995	17	5	0	0
7	4000	3995	17	5	0	0
8	4000	3995	16	4	1	0
9	4000	3995	16	3	2	0
10	4000	3992	20	3	5	0
11	4000	3991	26	4	5	0
12	4000	3990	20	5	5	0
13	4000	3988	46	7	5	0
14	4000	3988	45	7	5	0
15	4000	3986	45	9	5	0
16	4000	3986	45	9	5	0
17	4000	3983	43	12	5	0
18	4000	3982	43	11	7	0
19	4000	3980	39	10	10	0
20	4000	3978	38	11	11	0

Day	**Population**	**Susceptible**	**Exposed**	**Infected**	**Recovered**	**Dead**
21	3999	3972	30	16	11	1
22	3999	3969	44	18	12	1
23	3999	3968	50	18	13	1
24	3998	3966	53	18	14	2
25	3997	3965	54	17	15	3
26	3997	3965	64	16	16	3
27	3997	3963	75	18	16	3
28	3996	3956	95	23	17	4
29	3995	3952	130	23	20	5
30	3995	3949	161	22	24	5
32	3994	3937	234	29	28	6
33	3994	3932	308	33	29	6
34	3994	3923	378	42	29	6
35	3993	3913	459	50	30	7
36	3993	3889	620	72	32	7
37	3991	3869	635	87	35	9
38	3990	3855	643	96	39	10
39	3990	3823	669	125	42	10
40	3990	3786	679	157	47	10
41	3990	3743	693	192	55	10
42	3990	3689	667	239	62	10
43	3989	3634	683	281	74	11
44	3985	3584	686	314	87	15
45	3982	3538	680	344	100	18
46	3974	3489	677	366	119	26
47	3969	3449	663	381	139	31
48	3957	3412	636	387	158	43
49	3950	3370	596	378	202	50
50	3941	3321	571	387	233	59

Day	Population	Susceptible	Exposed	Infected	Recovered	Dead
51	3932	3272	1192	385	275	68
52	3923	3220	1699	386	317	77
53	3907	3180	2111	384	343	93
54	3894	3134	2359	378	382	106
55	3887	3109	2546	358	420	113
56	3878	3056	2616	370	452	122
57	3869	2938	2623	450	481	131
58	3857	2761	2520	576	520	143
59	3851	2554	2330	741	556	149
60	3843	2316	2105	925	602	157
61	3838	2077	1857	1122	639	162
62	3829	1862	1701	1290	677	171
63	3820	1715	1578	1406	699	180
64	3809	1589	1459	1463	757	191
65	3789	1483	1363	1480	826	211
66	3764	1370	1258	1455	939	236
67	3730	1253	1063	1389	1088	270
68	3695	1140	880	1291	1264	305
69	3647	1036	706	1151	1460	353
70	3609	952	575	1035	1622	391
71	3579	863	434	925	1791	421
72	3554	797	330	864	1893	446
73	3531	751	259	778	2002	469
74	3504	721	211	703	2080	496
75	3482	678	158	646	2158	518
76	3459	662	127	547	2250	541
77	3426	651	107	441	2334	574
78	3410	640	90	354	2416	590
79	3389	630	82	270	2489	611
80	3378	619	73	215	2544	622

Day	Population	Susceptible	Exposed	Infected	Recovered	Dead
81	3367	612	75	163	2592	633
82	3354	602	86	128	2624	646
83	3349	594	108	105	2650	651
84	3344	587	125	85	2672	656
85	3341	587	137	70	2684	659
86	3336	581	144	66	2689	664
87	3336	577	153	63	2696	664
88	3330	572	151	51	2707	670
89	3329	562	155	54	2713	671
90	3326	554	152	51	2721	674
91	3324	538	153	59	2727	676
92	3323	529	146	63	2731	677
93	3322	519	146	68	2735	678
94	3322	509	163	77	2736	678
95	3320	505	168	76	2739	680
96	3320	494	175	80	2746	680
97	3319	485	159	83	2751	681
98	3316	475	140	85	2756	684
99	3312	467	125	78	2767	688
100	3311	450	97	84	2777	689
101	3311	439	77	83	2789	689
102	3309	431	64	84	2794	691
103	3309	419	45	91	2799	691
104	3307	408	32	93	2806	693
105	3304	402	24	87	2815	696
106	3302	400	18	78	2824	698
107	3300	398	15	71	2831	700
108	3297	397	13	61	2839	703
109	3294	396	9	53	2845	706
110	3294	395	6	40	2859	706

Day	**Population**	**Susceptible**	**Exposed**	**Infected**	**Recovered**	**Dead**
111	3291	393	15	29	2869	709
112	3291	393	21	21	2877	709
113	3290	393	24	15	2882	710
114	3290	392	23	12	2886	710
115	3288	392	25	8	2888	712
116	3286	392	30	5	2889	714
117	3286	391	28	5	2890	714
118	3285	386	30	8	2891	715
119	3285	385	27	9	2891	715
120	3285	383	25	11	2891	715
121	3285	382	23	11	2892	715
122	3285	381	26	12	2892	715
123	3285	379	30	13	2893	715
124	3284	378	28	13	2893	716
125	3284	377	27	12	2895	716
126	3283	374	27	13	2896	717
127	3282	373	25	12	2897	718
128	3282	371	22	12	2899	718
129	3282	367	18	14	2901	718
130	3282	365	16	16	2901	718
131	3281	365	16	14	2902	719
132	3281	361	10	17	2903	719
133	3281	358	5	18	2905	719
134	3281	357	4	19	2905	719
135	3280	356	1	18	2906	720
136	3279	356	0	15	2908	721
137	3278	356	0	12	2910	722
138	3276	356	0	9	2911	724
139	3275	356	0	8	2911	725
140	3274	356	0	6	2912	726

Day	Population	Susceptible	Exposed	Infected	Recovered	Dead
141	3273	356	3	4	2913	727
142	3273	356	3	3	2914	727
143	3273	356	3	1	2916	727
144	3273	356	3	0	2917	727
145	3273	356	3	0	2917	727
146	3273	356	3	0	2917	727
147	3273	355	2	1	2917	727
148	3273	355	2	1	2917	727
149	3273	355	2	1	2917	727
150	3273	355	2	1	2917	727
151	3273	355	1	1	2917	727
152	3273	355	1	1	2917	727
153	3273	355	1	1	2917	727
154	3273	355	1	1	2917	727
155	3273	355	1	1	2917	727
156	3273	355	1	0	2918	727

Table I.5: Run 05: Time series table of the total number of population, susceptible, exposed, infected, recovered, and dead agents from day 1, the start of execution to day 156, when the number of exposed and infected agents became 0.

Appendix J

Figures for Scenario 04

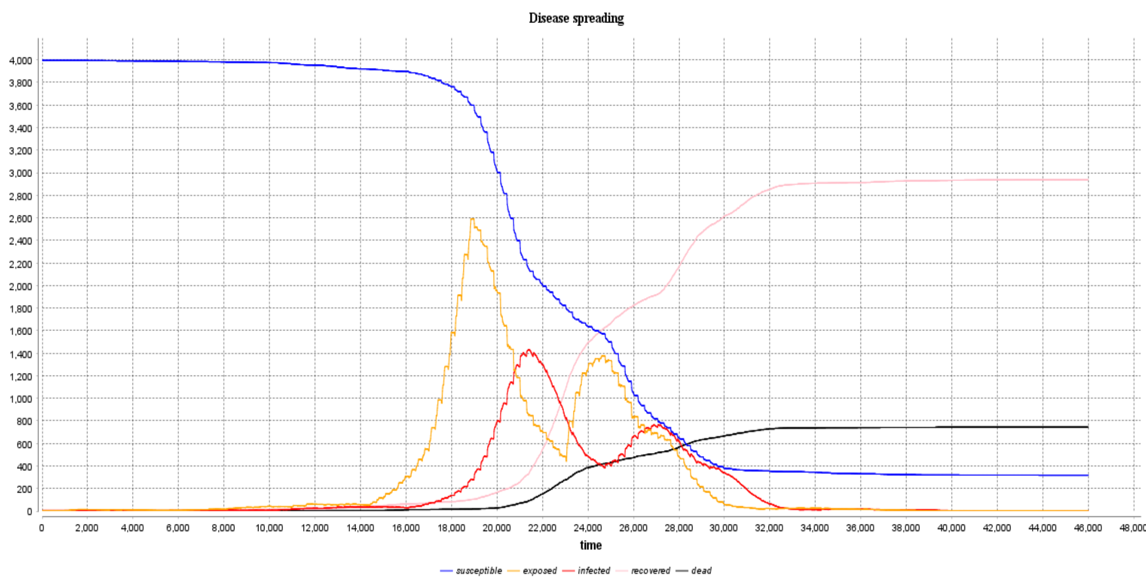

Figure J.1: Time Series chart of Scenario 04 Run 01.

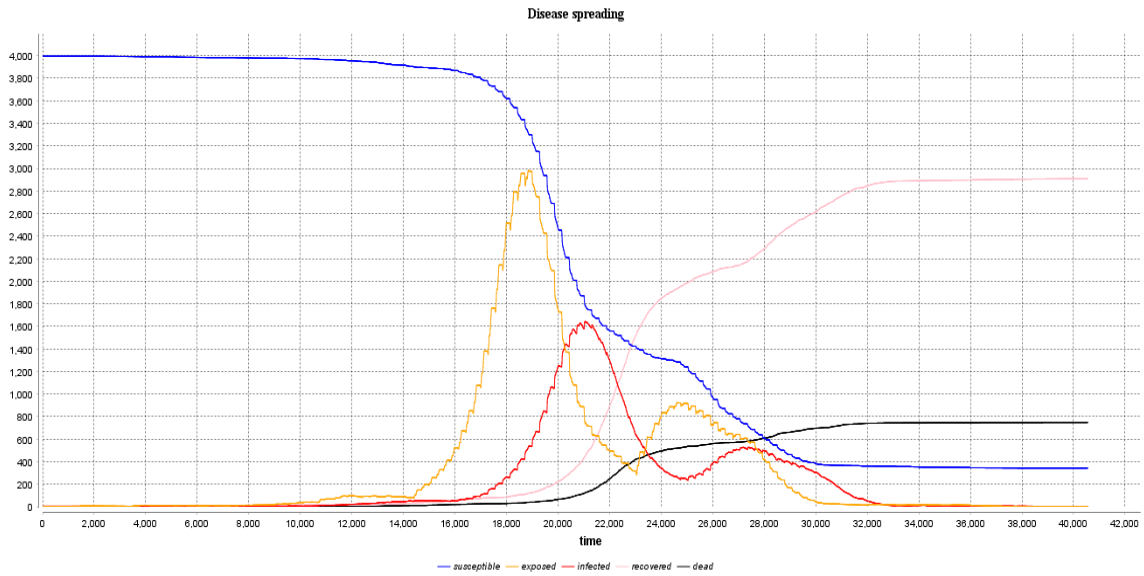

Figure J.2: Time Series chart of Scenario 04 Run 02.

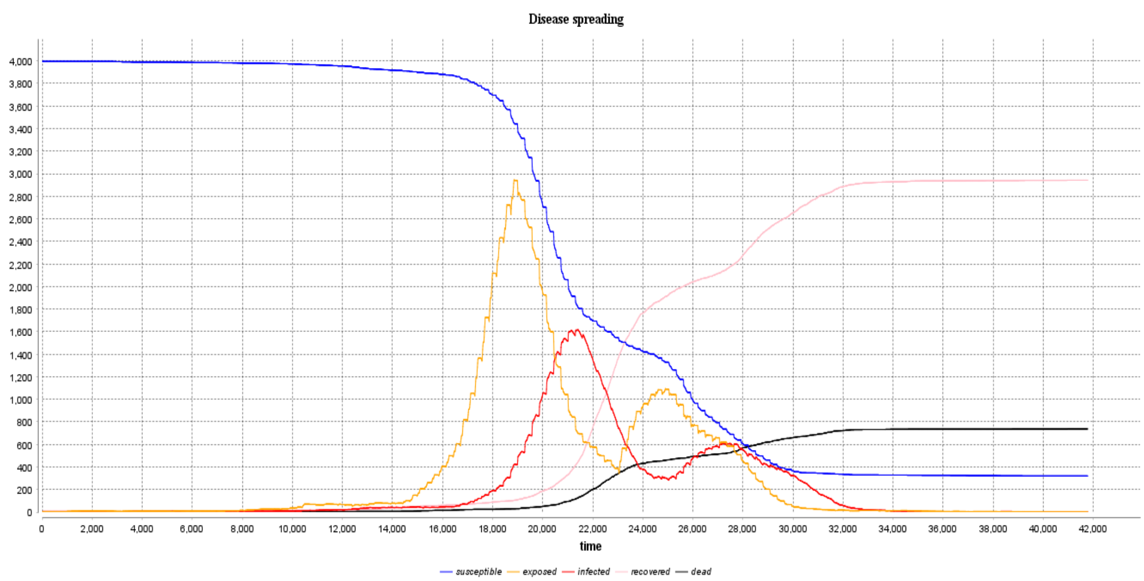

Figure J.3: Time Series chart of Scenario 04 Run 03.

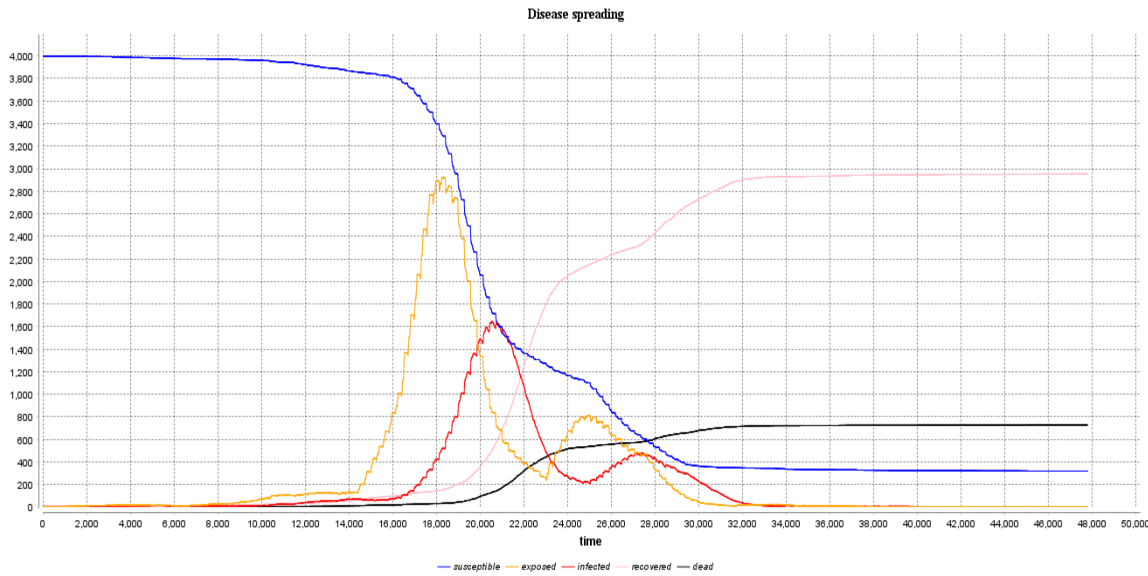

Figure J.4: Time Series chart of Scenario 04 Run 04.

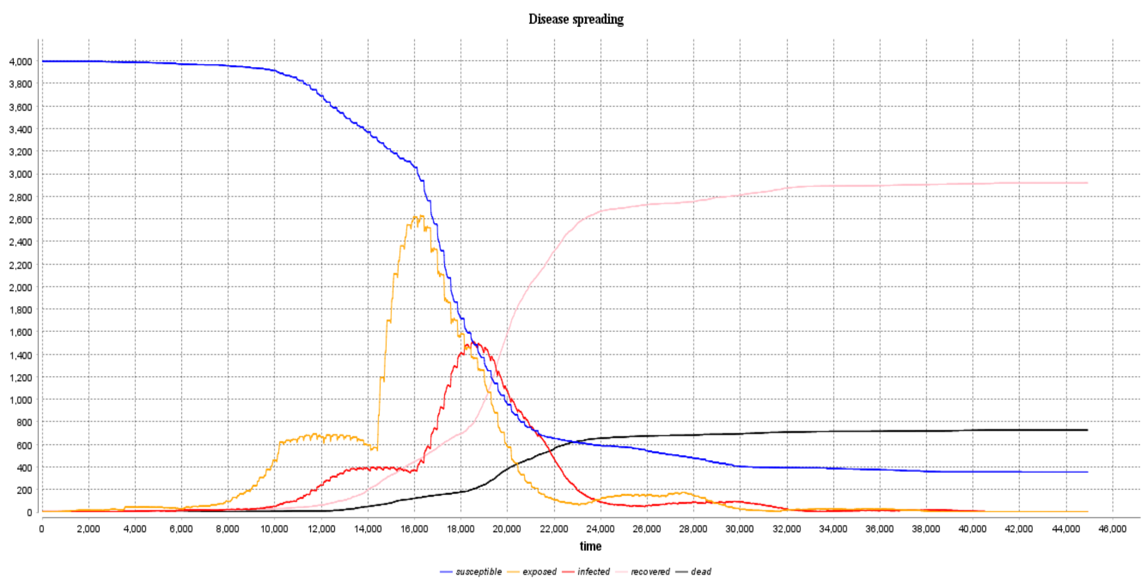

Figure J.5: Time Series chart of Scenario 04 Run 05.

Appendix K

Code for Scenario 01

```
model Scenario01

global {
    int nb_people <- 4000 update: 4000 - nb_people_dead;
    float agent_speed <- 5.0 #km / #h;
    float step <- 5 #minutes;
    float expose_distance <- 2.0 #m;
    float proba_infection <- 0.50;
    float proba_recover <- 0.80; /* 80% chance of recovering */
    int nb_infected_init <- 5;
    int nb_exposed_init <- 0;
    int nb_recovered_init <- 0;
    int nb_immune_init <- 0; /* immune only if already recovered */
    int nb_dead_init <- 0;
    file roads_shapefile <- file("../includes/road.shp");
    file buildings_shapefile <- file("../includes/building.shp");
    geometry shape <- envelope(buildings_shapefile);
    graph road_network;
    /* Makulit at hours: 9-11am, 3-6pm. At these times, agent has a more chance to leave the building*/
    float staying_coeff update: 10.0 ^ (1 + min([abs(current_date.hour - 9), abs(current_date.hour - 10),
        abs(current_date.hour - 11), abs(current_date.hour - 15), abs(current_date.hour - 16),
        abs(current_date.hour - 17), abs(current_date.hour - 18)]));
    list<people_in_building> list_people_in_buildings update: (building accumulate each.people_in_building);
    int nb_people_susceptible <- nb_people - nb_infected_init update: (nb_people - nb_people_infected
        - nb_people_recovered);
    int nb_people_infected <- nb_infected_init update: (people + list_people_in_buildings) count
        (each.is_infected);
    int nb_people_not_infected <- nb_people - nb_infected_init update: (nb_people - nb_people_infected);
    int nb_people_exposed <- nb_exposed_init update: (people + list_people_in_buildings) count
        (each.is_exposed);
    int nb_people_not_exposed <- nb_people - nb_exposed_init update: (nb_people - nb_people_exposed);
    int nb_people_recovered <- nb_recovered_init update: (people + list_people_in_buildings)
        count (each.is_recovered);
    int nb_people_not_recovered <- nb_people - nb_recovered_init update: (nb_people - nb_people_recovered);
    int nb_people_immune <- nb_immune_init update: (people + list_people_in_buildings) count
        (each.is_immune);
    int nb_people_not_immune <- nb_people - nb_immune_init update: (nb_people - nb_people_immune);
    int nb_people_dead <- nb_dead_init update: (people + list_people_in_buildings) count
```

```
        (each.is_dead);
    int nb_people_not_dead <- nb_people - nb_dead_init update: (nb_people - nb_people_dead);
    int current_day <- 1 update: current_date.hour = 0 and current_date.minute = 0 ? current_day + 1 :
        current_day;
    /* night is before 7am and after 8pm */
    bool is_night <- true update: current_date.hour < 7 or current_date.hour > 20;
    float infected_rate update: nb_people_infected / nb_people;
    /* list<int> nb_susceptible <- [3995]; */


    init {
        create road from: roads_shapefile;
        road_network <- as_edge_graph(road);
        create building from: buildings_shapefile;
        create people number: nb_people {
            speed <- agent_speed;
            building bd <- one_of(building);
            location <- any_location_in(bd);
        }

        ask nb_infected_init among people {
            is_infected <- true;
            time_infected <- 0;
            infected_will_recover_or_die <- rnd(2016,2880); /* will recover or die after 7-10 days */
        }
    }

    reflex end_simulation when: infected_rate = 1.0 or (nb_people_infected = 0 and nb_people_exposed = 0) {
        do pause;
    }
}

species people skills: [moving] {
    bool is_infected <- false;
    bool is_exposed <- false;
    bool is_recovered <- false;
    bool is_immune <- false;
    bool is_dead <- false;
    int time_exposed <- 0;
    int time_infected <- 0;
    int time_recovered <- 0;
    int time_dead <- 0;
    int exposed_will_be_infected <- 0;
    int infected_will_recover_or_die <- 0;
    point target;
    int staying_counter;
    int expose_counter <- 0;
```

```
reflex stay when: target = nil {
    staying_counter <- staying_counter + 1;
    if flip(staying_counter / staying_coeff) {
        target <- any_location_in (one_of(building));
    }
}

reflex move when: target != nil {
    do goto target: target on: road_network;
    if (location = target) {
        target <- nil;
        staying_counter <- 0;
    }

}

reflex expose when: is_infected {
    ask people at_distance expose_distance {
        if (is_dead){
            is_dead <- true;
        }else if (is_immune){
            is_recovered <- true;
            is_infected <- false;
            is_exposed <- false;
        }else if (is_infected){
            is_infected <- true;
            is_exposed <- false;
            is_recovered <- false;
        }else{
            expose_counter <- expose_counter + 1;
            if (expose_counter = 3){ /* Must be exposed for 3 cycles (15 mins) before to be
            considered as exposed */
                is_exposed <- true;
                is_infected <- false;
                is_recovered <- false;
                time_exposed <- cycle;
                exposed_will_be_infected <- rnd(1440,2880); /* exposed will be infected after 5-10
                    days */
            }
            if (cycle mod 288 = 0){ /* Reset everyday */
                expose_counter <- 0;
            }
        }
    }
}
```

```
reflex infect when: is_exposed {
    if(is_immune = false and is_recovered = false and is_dead = false){
        if ((cycle - time_exposed) >= exposed_will_be_infected) { /* will determine if infected
        after 3-10 days of being exposed */
            if flip(rnd(0.3,0.8)) {
                /* write "Infected"; */
                is_infected <- true;
                is_exposed <- false;
                is_recovered <- false;
                time_infected <- cycle;
                time_exposed <- 0;
                infected_will_recover_or_die <- rnd(2016,2880); /* will recover or die after
                    7-10 days */
            }else{
                /* write "Not Infected"; */
                is_infected <- false;
                is_exposed <- false;
                is_recovered <- false;
                is_immune <- false;
                is_dead <- false;
                time_exposed <- 0;
                time_infected <- 0;
                expose_counter <- 0;
            }
        }
    }
}

reflex recover when: is_infected {
    if((cycle - time_infected) >= infected_will_recover_or_die){ /* if infected for 7-14 days */
        if flip(proba_recover){ /* If agent will recover */
            is_immune <- true;
            is_recovered <- true;
            is_infected <- false;
            is_exposed <- false;
            is_dead <- false;
            time_recovered <- cycle;
        }else{ /* Else, agent will be dead */
            is_dead <- true;
            is_recovered <- false;
            is_immune <- false;
            is_infected <- false;
            is_exposed <- false;
            time_dead <- cycle;
        }
    }
}
```

```
    aspect circle {
        draw circle(1) color: is_exposed ? #orange : (is_infected ? #red : (is_recovered ? #pink :
            (is_dead ? #black : #blue)));
    }

    aspect sphere3D {
        draw sphere(2) at: {location.x, location.y, location.z + 2} color: is_exposed ? #orange :
            (is_infected ? #red : (is_recovered ? #pink : (is_dead ? #black : #blue)));
    }

}

species road {
    geometry display_shape <- shape + 2.0;
    aspect default {
        draw display_shape color: #black depth: 3.0;
    }
}

species building {
    int nb_infected <- 0 update: self.people_in_building count each.is_infected;
    int nb_exposed <- 0 update: self.people_in_building count each.is_exposed;
    int nb_recovered <- 0 update: self.people_in_building count each.is_recovered;
    int nb_dead <- 0 update: self.people_in_building count each.is_dead;
    int nb_total <- 0 update: length(self.people_in_building);
    float height <- rnd(10 #m, 20 #m);

    species people_in_building parent: people schedules: [] {
    }

    reflex let_people_leave {
        ask people_in_building {
            staying_counter <- staying_counter + 1;
        }

        release people_in_building where (flip(each.staying_counter / staying_coeff)) as: people in:
        world {
            target <- any_location_in(one_of(building));
        }

    }

    reflex let_people_enter {
        capture (people inside self where (each.target = nil)) as: people_in_building;
    }
```

```
    aspect default {
        draw shape color: nb_total = 0 ? #gray : (float(nb_infected) / nb_total > 0.5 ? #red : #green)
        border: #black depth: height;
    }
}

experiment main_experiment type: gui { /* experiment with a graphical interface */
    parameter "Initial Population" var: nb_people;
    parameter "Exposure distance" var: expose_distance;
    /* parameter "Proba infection" var: proba_infection min: 0.0 max: 1.0; */
    parameter "Nb people infected at init" var: nb_infected_init;
    output {
        monitor "Day" value: current_day;
        monitor "Total Population" value: nb_people;
        monitor "Number of Susceptible" value: nb_people_susceptible;
        monitor "Number of Exposed" value: nb_people_exposed;
        monitor "Number of Infected" value: nb_people_infected;
        monitor "Number of Recovered" value: nb_people_recovered;
        monitor "Number of Dead" value: nb_people_dead;
        monitor "Current hour" value: current_date.hour;
        monitor "Current minute" value: current_date.minute;
        monitor "Infected people rate" value: infected_rate;

        display view3D type: opengl antialias: false {
            light #ambient intensity: 20;
            light #default intensity:(is_night ? 127 : 255); /*  intensity of the light to 127 during
                the night, and 255 for the day */
            /* image "../includes/soil.jpg" refresh: false;  */
            species road;
            species people aspect: sphere3D;
            species building transparency: 0.3;
        }

        display chart_display refresh: every(10 #cycles) {
            chart "Disease spreading" type: series {
                data "susceptible" value: nb_people_susceptible color: #blue marker: false;
                data "exposed" value: nb_people_exposed color: #orange marker: false;
                data "infected" value: nb_people_infected color: #red marker: false;
                data "recovered" value: nb_people_recovered color: #pink marker: false;
                data "dead" value: nb_people_dead color: #black marker: false;
            }
        }
    }

}

/* Code by Lyka Raquel C. Lim */
```

Appendix L

Code for Scenario 02.1

```
model Scenario021

global {
    int nb_people <- 4000 update: 4000 - nb_people_dead;
    float agent_speed <- 5.0 #km / #h;
    float step <- 5 #minutes;
    float expose_distance <- 2.0 #m;
    float proba_infection <- 0.50;
    float proba_recover <- 0.80; /* 80% chance of recovering */
    int nb_infected_init <- 10;
    int nb_exposed_init <- 0;
    int nb_recovered_init <- 0;
    int nb_immune_init <- 0; /* immune only if already recovered */
    int nb_dead_init <- 0;
    file roads_shapefile <- file("../includes/road.shp");
    file buildings_shapefile <- file("../includes/building.shp");
    geometry shape <- envelope(buildings_shapefile);
    graph road_network;
    /* Makulit at hours: 9-11am, 3-6pm. At these times, agent has a more chance to leave the building*/
    float staying_coeff update: 10.0 ^ (1 + min([abs(current_date.hour - 9), abs(current_date.hour - 10),
        abs(current_date.hour - 11), abs(current_date.hour - 15), abs(current_date.hour - 16),
        abs(current_date.hour - 17), abs(current_date.hour - 18)]));
    list<people_in_building> list_people_in_buildings update: (building accumulate each.people_in_building);
    int nb_people_susceptible <- nb_people - nb_infected_init update: (nb_people - nb_people_infected -
        nb_people_recovered);
    int nb_people_infected <- nb_infected_init update: (people + list_people_in_buildings) count
        (each.is_infected);
    int nb_people_not_infected <- nb_people - nb_infected_init update: (nb_people - nb_people_infected);
    int nb_people_exposed <- nb_exposed_init update: (people + list_people_in_buildings) count
        (each.is_exposed);
    int nb_people_not_exposed <- nb_people - nb_exposed_init update: (nb_people - nb_people_exposed);
    int nb_people_recovered <- nb_recovered_init update: (people + list_people_in_buildings) count
        (each.is_recovered);
    int nb_people_not_recovered <- nb_people - nb_recovered_init update: (nb_people- nb_people_recovered);
    int nb_people_immune <- nb_immune_init update: (people + list_people_in_buildings) count
        (each.is_immune);
    int nb_people_not_immune <- nb_people - nb_immune_init update: (nb_people - nb_people_immune);
    int nb_people_dead <- nb_dead_init update: (people + list_people_in_buildings) count (each.is_dead);
```

```
    int nb_people_not_dead <- nb_people - nb_dead_init update: (nb_people - nb_people_dead);
    int current_day <- 1 update: current_date.hour = 0 and current_date.minute = 0 ? current_day +
        1 : current_day;
    /* night is before 7am and after 8pm */
    bool is_night <- true update: current_date.hour < 7 or current_date.hour > 20;
    bool lockdown <- true update: (current_day > 6 and current_day < 21) or (current_day > 36 and
        current_day < 51) or (current_day > 66 and current_day < 81) or (current_day > 96 and
        current_day < 111) or (current_day > 126 and current_day < 141) or (current_day > 156
        and current_day < 171); /* lockdown every 2nd and 3rd week of the month */
    float infected_rate update: nb_people_infected / nb_people;


    init {
        create road from: roads_shapefile;
        road_network <- as_edge_graph(road);
        create building from: buildings_shapefile;
        create people number: nb_people {
            speed <- agent_speed;
            building bd <- one_of(building);
            location <- any_location_in(bd);
        }

        ask nb_infected_init among people {
            is_infected <- true;
            time_infected <- 0;
            infected_will_recover_or_die <- rnd(2016,2880); /* will recover or die after 7-10 days */
        }
    }

    reflex end_simulation when: infected_rate = 1.0 or (nb_people_infected = 0 and nb_people_exposed = 0) {
        do pause;
    }
}

species people skills: [moving] {
    bool is_infected <- false;
    bool is_exposed <- false;
    bool is_recovered <- false;
    bool is_immune <- false;
    bool is_dead <- false;
    int time_exposed <- 0;
    int time_infected <- 0;
    int time_recovered <- 0;
    int time_dead <- 0;
    int exposed_will_be_infected <- 0;
    int infected_will_recover_or_die <- 0;
    point target;
```

```
int staying_counter;
int expose_counter <- 0;
int lockdown_day <- 0;

reflex lockdown when: lockdown{
    target <- nil;
    staying_counter <- 0;
    if flip(staying_counter / staying_coeff) { /* If mababa percentage, no new target */
        target <- any_location_in (one_of(building));
    }
}

reflex stay when: target = nil and not lockdown{
    staying_counter <- staying_counter + 1;
    if flip(staying_counter / staying_coeff) { /* If mababa percentage, no new target */
        target <- any_location_in (one_of(building));
    }
}

reflex move when: target != nil{
    do goto target: target on: road_network;
    if (location = target) {
        target <- nil;
        staying_counter <- 0;
    }

}

reflex expose when: is_infected {
    ask people at_distance expose_distance {
        if (is_dead){
            is_dead <- true;
        }else if (is_immune){
            is_recovered <- true;
            is_infected <- false;
            is_exposed <- false;
        }else if (is_infected){
            is_infected <- true;
            is_exposed <- false;
            is_recovered <- false;
        }else{
            expose_counter <- expose_counter + 1;
            if (expose_counter = 3){ /* Must be exposed for 3 cycles (15 mins) before to be
            considered as exposed */
                is_exposed <- true;
                is_infected <- false;
                is_recovered <- false;
```

```
                time_exposed <- cycle;
                exposed_will_be_infected <- rnd(1440,2880); /* exposed will be infected after
                    5-10 days */
            }
            if (cycle mod 288 = 0){ /* Reset everyday */
                expose_counter <- 0;
            }
        }
    }
}

reflex infect when: is_exposed {
    if(is_immune = false and is_recovered = false and is_dead = false){
        if ((cycle - time_exposed) >= exposed_will_be_infected) { /* will determine if infected
        after 3-10 days of being exposed */
            if flip(rnd(0.3,0.8)) {
                /* write "Infected"; */
                is_infected <- true;
                is_exposed <- false;
                is_recovered <- false;
                time_infected <- cycle;
                time_exposed <- 0;
                infected_will_recover_or_die <- rnd(2016,2880); /* will recover or die after
                    7-10 days */
            }else{
                /* write "Not Infected"; */
                is_infected <- false;
                is_exposed <- false;
                is_recovered <- false;
                is_immune <- false;
                is_dead <- false;
                time_exposed <- 0;
                time_infected <- 0;
                expose_counter <- 0;
            }
        }
    }
}

reflex recover when: is_infected {
    if((cycle - time_infected) >= infected_will_recover_or_die){ /* if infected for 7-14 days */
        if flip(proba_recover){ /* If agent will recover */
            is_immune <- true;
            is_recovered <- true;
            is_infected <- false;
            is_exposed <- false;
            is_dead <- false;
```

```
                time_recovered <- cycle;
            }else{ /* Else, agent will be dead */
                is_dead <- true;
                is_recovered <- false;
                is_immune <- false;
                is_infected <- false;
                is_exposed <- false;
                time_dead <- cycle;
            }
        }
    }

    aspect circle {
        draw circle(1) color: is_exposed ? #orange : (is_infected ? #red : (is_recovered ? #pink :
        (is_dead ? #black : #blue)));
    }

    aspect sphere3D {
        draw sphere(2) at: {location.x, location.y, location.z + 2} color: is_exposed ? #orange :
        (is_infected ? #red : (is_recovered ? #pink : (is_dead ? #black : #blue)));
    }

}

species road {
    geometry display_shape <- shape + 2.0;
    aspect default {
        draw display_shape color: #black depth: 3.0;
    }
}

species building {
    int nb_infected <- 0 update: self.people_in_building count each.is_infected;
    int nb_exposed <- 0 update: self.people_in_building count each.is_exposed;
    int nb_recovered <- 0 update: self.people_in_building count each.is_recovered;
    int nb_dead <- 0 update: self.people_in_building count each.is_dead;
    int nb_total <- 0 update: length(self.people_in_building);
    float height <- rnd(10 #m, 20 #m);

    species people_in_building parent: people schedules: [] {
    }

    reflex let_people_leave {
        ask people_in_building {
            staying_counter <- staying_counter + 1;
        }
```

```
        release people_in_building where (flip(each.staying_counter / staying_coeff)) as: people in:
        world {
            target <- any_location_in(one_of(building));
        }

    }

    reflex let_people_enter {
        capture (people inside self where (each.target = nil)) as: people_in_building;
    }

    aspect default {
        draw shape color: nb_total = 0 ? #gray : (float(nb_infected) / nb_total > 0.5 ? #red : #green)
        border: #black depth: height;
    }
}

experiment main_experiment type: gui { /* experiment with a graphical interface */
    parameter "Initial Population" var: nb_people;
    parameter "Exposure distance" var: expose_distance;
    /* parameter "Proba infection" var: proba_infection min: 0.0 max: 1.0; */
    parameter "Nb people infected at init" var: nb_infected_init;
    output {
        monitor "Day" value: current_day;
        monitor "Total Population" value: nb_people;
        monitor "Number of Susceptible" value: nb_people_susceptible;
        monitor "Number of Exposed" value: nb_people_exposed;
        monitor "Number of Infected" value: nb_people_infected;
        monitor "Number of Recovered" value: nb_people_recovered;
        monitor "Number of Dead" value: nb_people_dead;
        monitor "Current hour" value: current_date.hour;
        monitor "Current minute" value: current_date.minute;
        monitor "Infected people rate" value: infected_rate;

        display view3D type: opengl antialias: false {
            light #ambient intensity: 20;
            light #default intensity:(is_night ? 127 : 255); /*  intensity of the light to 127 during the
                night, and 255 for the day */
            /* image "../includes/soil.jpg" refresh: false;  */
            species road;
            species people aspect: sphere3D;
            species building transparency: 0.3;
        }

        display chart_display refresh: every(10 #cycles) {
            chart "Disease spreading" type: series {
                data "susceptible" value: nb_people_susceptible color: #blue marker: false;
```

```
                data "exposed" value: nb_people_exposed color: #orange marker: false;
                data "infected" value: nb_people_infected color: #red marker: false;
                data "recovered" value: nb_people_recovered color: #pink marker: false;
                data "dead" value: nb_people_dead color: #black marker: false;
            }
        }
    }

}

/* Code by Lyka Raquel C. Lim */
```

Appendix M

Code for Scenario 02.2

```
model Scenario022

global {
    int nb_people <- 4000 update: 4000 - nb_people_dead;
    float agent_speed <- 5.0 #km / #h;
    float step <- 5 #minutes;
    float expose_distance <- 2.0 #m;
    float proba_infection <- 0.50;
    float proba_recover <- 0.80; /* 80% chance of recovering */
    int nb_infected_init <- 5;
    int nb_exposed_init <- 0;
    int nb_recovered_init <- 0;
    int nb_immune_init <- 0; /* immune only if already recovered */
    int nb_dead_init <- 0;
    file roads_shapefile <- file("../includes/road.shp");
    file buildings_shapefile <- file("../includes/building.shp");
    geometry shape <- envelope(buildings_shapefile);
    graph road_network;
    /* Makulit at hours: 9-11am, 3-6pm. At these times, agent has a more chance to leave the building*/
    float staying_coeff update: 10.0 ^ (1 + min([abs(current_date.hour - 9), abs(current_date.hour - 10),
        abs(current_date.hour - 11), abs(current_date.hour - 15), abs(current_date.hour - 16),
        abs(current_date.hour - 17), abs(current_date.hour - 18)]));
    list<people_in_building> list_people_in_buildings update: (building accumulate each.people_in_building);
    int nb_people_susceptible <- nb_people - nb_infected_init update: (nb_people - nb_people_infected -
        nb_people_recovered);
    int nb_people_infected <- nb_infected_init update: (people + list_people_in_buildings) count
        (each.is_infected);
    int nb_people_not_infected <- nb_people - nb_infected_init update: (nb_people - nb_people_infected);
    int nb_people_exposed <- nb_exposed_init update: (people + list_people_in_buildings) count
        (each.is_exposed);
    int nb_people_not_exposed <- nb_people - nb_exposed_init update: (nb_people - nb_people_exposed);
    int nb_people_recovered <- nb_recovered_init update: (people + list_people_in_buildings) count
        (each.is_recovered);
    int nb_people_not_recovered <- nb_people - nb_recovered_init update: (nb_people - nb_people_recovered);
    int nb_people_immune <- nb_immune_init update: (people + list_people_in_buildings) count (each.is_immune);
    int nb_people_not_immune <- nb_people - nb_immune_init update: (nb_people - nb_people_immune);
    int nb_people_dead <- nb_dead_init update: (people + list_people_in_buildings) count (each.is_dead);
    int nb_people_not_dead <- nb_people - nb_dead_init update: (nb_people - nb_people_dead);
```

```
    int current_day <- 1 update: current_date.hour = 0 and current_date.minute = 0 ? current_day + 1 :
        current_day;
    /* night is before 7am and after 8pm */
    bool is_night <- true update: current_date.hour < 7 or current_date.hour > 20;
    bool lockdown <- true update: (current_day > 13 and current_day < 28) or (current_day > 43 and
        current_day < 58) or (current_day > 103 and current_day < 118) or (current_day > 133 and
        current_day < 148) or (current_day > 163 and current_day < 178); /* lockdown every 3rd
        and 4th week of the month */
    float infected_rate update: nb_people_infected / nb_people;


    init {
        create road from: roads_shapefile;
        road_network <- as_edge_graph(road);
        create building from: buildings_shapefile;
        create people number: nb_people {
            speed <- agent_speed;
            building bd <- one_of(building);
            location <- any_location_in(bd);
        }

        ask nb_infected_init among people {
            is_infected <- true;
            time_infected <- 0;
            infected_will_recover_or_die <- rnd(2016,2880); /* will recover or die after 7-10 days */
        }
    }

    reflex end_simulation when: infected_rate = 1.0 or (nb_people_infected = 0 and nb_people_exposed = 0) {
        do pause;
    }
}

species people skills: [moving] {
    bool is_infected <- false;
    bool is_exposed <- false;
    bool is_recovered <- false;
    bool is_immune <- false;
    bool is_dead <- false;
    int time_exposed <- 0;
    int time_infected <- 0;
    int time_recovered <- 0;
    int time_dead <- 0;
    int exposed_will_be_infected <- 0;
    int infected_will_recover_or_die <- 0;
    point target;
    int staying_counter;
```

```
int expose_counter <- 0;
int lockdown_day <- 0;

reflex lockdown when: lockdown{
    target <- nil;
    staying_counter <- 0;
    if flip(staying_counter / staying_coeff) { /* If mababa percentage, no new target */
        target <- any_location_in (one_of(building));
    }
}

reflex stay when: target = nil and not lockdown{
    staying_counter <- staying_counter + 1;
    if flip(staying_counter / staying_coeff) { /* If mababa percentage, no new target */
        target <- any_location_in (one_of(building));
    }
}

reflex move when: target != nil{
    do goto target: target on: road_network;
    if (location = target) {
        target <- nil;
        staying_counter <- 0;
    }

}

reflex expose when: is_infected {
    ask people at_distance expose_distance {
        if (is_dead){
            is_dead <- true;
        }else if (is_immune){
            is_recovered <- true;
            is_infected <- false;
            is_exposed <- false;
        }else if (is_infected){
            is_infected <- true;
            is_exposed <- false;
            is_recovered <- false;
        }else{
            expose_counter <- expose_counter + 1;
            if (expose_counter = 3){ /* Must be exposed for 3 cycles (15 mins) before to be
            considered as exposed */
                is_exposed <- true;
                is_infected <- false;
                is_recovered <- false;
                time_exposed <- cycle;
```

```
                exposed_will_be_infected <- rnd(1440,2880); /* exposed will be infected after
                5-10 days */
            }
            if (cycle mod 288 = 0){ /* Reset everyday */
                expose_counter <- 0;
            }
        }
    }
}

reflex infect when: is_exposed {
    if(is_immune = false and is_recovered = false and is_dead = false){
        if ((cycle - time_exposed) >= exposed_will_be_infected) { /* will determine if infected
        after 3-10 days of being exposed */
            if flip(rnd(0.3,0.8)) {
                /* write "Infected"; */
                is_infected <- true;
                is_exposed <- false;
                is_recovered <- false;
                time_infected <- cycle;
                time_exposed <- 0;
                infected_will_recover_or_die <- rnd(2016,2880); /* will recover or die after
                    7-10 days */
            }else{
                /* write "Not Infected"; */
                is_infected <- false;
                is_exposed <- false;
                is_recovered <- false;
                is_immune <- false;
                is_dead <- false;
                time_exposed <- 0;
                time_infected <- 0;
                expose_counter <- 0;
            }
        }
    }
}

reflex recover when: is_infected {
    if((cycle - time_infected) >= infected_will_recover_or_die){ /* if infected for 7-14 days */
        if flip(proba_recover){ /* If agent will recover */
            is_immune <- true;
            is_recovered <- true;
            is_infected <- false;
            is_exposed <- false;
            is_dead <- false;
            time_recovered <- cycle;
```

```
            }else{ /* Else, agent will be dead */
                is_dead <- true;
                is_recovered <- false;
                is_immune <- false;
                is_infected <- false;
                is_exposed <- false;
                time_dead <- cycle;
            }
        }
    }

    aspect circle {
        draw circle(1) color: is_exposed ? #orange : (is_infected ? #red : (is_recovered ? #pink :
        (is_dead ? #black : #blue)));
    }

    aspect sphere3D {
        draw sphere(2) at: {location.x, location.y, location.z + 2} color: is_exposed ? #orange :
        (is_infected ? #red : (is_recovered ? #pink : (is_dead ? #black : #blue)));
    }

}

species road {
    geometry display_shape <- shape + 2.0;
    aspect default {
        draw display_shape color: #black depth: 3.0;
    }
}

species building {
    int nb_infected <- 0 update: self.people_in_building count each.is_infected;
    int nb_exposed <- 0 update: self.people_in_building count each.is_exposed;
    int nb_recovered <- 0 update: self.people_in_building count each.is_recovered;
    int nb_dead <- 0 update: self.people_in_building count each.is_dead;
    int nb_total <- 0 update: length(self.people_in_building);
    float height <- rnd(10 #m, 20 #m);

    species people_in_building parent: people schedules: [] {
    }

    reflex let_people_leave {
        ask people_in_building {
            staying_counter <- staying_counter + 1;
        }

        release people_in_building where (flip(each.staying_counter / staying_coeff)) as: people
```

```
        in: world {
            target <- any_location_in(one_of(building));
        }

    }

    reflex let_people_enter {
        capture (people inside self where (each.target = nil)) as: people_in_building;
    }

    aspect default {
        draw shape color: nb_total = 0 ? #gray : (float(nb_infected) / nb_total > 0.5 ? #red : #green)
        border: #black depth: height;
    }
}

experiment main_experiment type: gui { /* experiment with a graphical interface */
    parameter "Initial Population" var: nb_people;
    parameter "Exposure distance" var: expose_distance;
    /* parameter "Proba infection" var: proba_infection min: 0.0 max: 1.0; */
    parameter "Nb people infected at init" var: nb_infected_init;
    output {
        monitor "Day" value: current_day;
        monitor "Total Population" value: nb_people;
        monitor "Number of Susceptible" value: nb_people_susceptible;
        monitor "Number of Exposed" value: nb_people_exposed;
        monitor "Number of Infected" value: nb_people_infected;
        monitor "Number of Recovered" value: nb_people_recovered;
        monitor "Number of Dead" value: nb_people_dead;
        monitor "Current hour" value: current_date.hour;
        monitor "Current minute" value: current_date.minute;
        monitor "Infected people rate" value: infected_rate;

        display view3D type: opengl antialias: false {
            light #ambient intensity: 20;
            light #default intensity:(is_night ? 127 : 255); /*  intensity of the light to 127 during
                the night, and 255 for the day */
            /* image "../includes/soil.jpg" refresh: false;  */
            species road;
            species people aspect: sphere3D;
            species building transparency: 0.3;
        }

        display chart_display refresh: every(10 #cycles) {
            chart "Disease spreading" type: series {
                data "susceptible" value: nb_people_susceptible color: #blue marker: false;
                data "exposed" value: nb_people_exposed color: #orange marker: false;
```

```
                data "infected" value: nb_people_infected color: #red marker: false;
                data "recovered" value: nb_people_recovered color: #pink marker: false;
                data "dead" value: nb_people_dead color: #black marker: false;
            }
        }
    }

}

/* Code by Lyka Raquel C. Lim */
```

Appendix N

Code for Scenario 03

```
model Scenario03

global {
    int nb_people <- 4000 update: 4000 - nb_people_dead;
    float agent_speed <- 5.0 #km / #h;
    float step <- 5 #minutes;
    float expose_distance <- 2.0 #m;
    float proba_infection <- 0.50;
    float proba_recover <- 0.80; /* 80% chance of recovering */
    int nb_infected_init <- 5;
    int nb_exposed_init <- 0;
    int nb_recovered_init <- 0;
    int nb_immune_init <- 0; /* immune only if already recovered */
    int nb_dead_init <- 0;
    file roads_shapefile <- file("../includes/road.shp");
    file buildings_shapefile <- file("../includes/NonQ_building.shp");
    file qbuildings_shapefile <- file("../includes/Q_building.shp");
    geometry shape <- envelope(buildings_shapefile);
    graph road_network;
    /* Makulit at hours: 9-11am, 3-6pm. At these times, agent has a more chance to leave the building*/
    float staying_coeff update: 10.0 ^ (1 + min([abs(current_date.hour - 9), abs(current_date.hour - 10),
        abs(current_date.hour - 11), abs(current_date.hour - 15), abs(current_date.hour - 16),
        abs(current_date.hour - 17), abs(current_date.hour - 18)]));
    list<people_in_building> list_people_in_buildings update: (building accumulate each.people_in_building);
    int nb_people_susceptible <- nb_people - nb_infected_init update: (nb_people - nb_people_infected -
        nb_people_recovered);
    int nb_people_infected <- nb_infected_init update: (people + list_people_in_buildings) count
        (each.is_infected);
    int nb_people_not_infected <- nb_people - nb_infected_init update: (nb_people - nb_people_infected);
    int nb_people_exposed <- nb_exposed_init update: (people + list_people_in_buildings) count
        (each.is_exposed);
    int nb_people_not_exposed <- nb_people - nb_exposed_init update: (nb_people - nb_people_exposed);
    int nb_people_recovered <- nb_recovered_init update: (people + list_people_in_buildings) count
        (each.is_recovered);
    int nb_people_not_recovered <- nb_people - nb_recovered_init update: (nb_people - nb_people_recovered);
    int nb_people_immune <- nb_immune_init update: (people + list_people_in_buildings) count
        (each.is_immune);
    int nb_people_not_immune <- nb_people - nb_immune_init update: (nb_people - nb_people_immune);
```

```
    int nb_people_dead <- nb_dead_init update: (people + list_people_in_buildings) count (each.is_dead);
    int nb_people_not_dead <- nb_people - nb_dead_init update: (nb_people - nb_people_dead);
    int current_day <- 1 update: current_date.hour = 0 and current_date.minute = 0 ? current_day + 1 :
        current_day;
    /* night is before 7am and after 8pm */
    bool is_night <- true update: current_date.hour < 7 or current_date.hour > 20;
    float infected_rate update: nb_people_infected / nb_people;


    init {
        create road from: roads_shapefile;
        road_network <- as_edge_graph(road);
        create building from: buildings_shapefile;
        create qbuilding from: qbuildings_shapefile;
        create people number: nb_people {
            speed <- agent_speed;
            building bd <- one_of(building);
            location <- any_location_in(bd);
        }

        ask nb_infected_init among people {
            is_infected <- true;
            time_infected <- 0;
            infected_will_recover_or_die <- rnd(2016,2880); /* will recover or die after 7-10 days */
            /* write "Infected at: " + time_infected + ", will recover at " + infected_will_recover_or_die; */
        }
    }

    reflex end_simulation when: infected_rate = 1.0 or (nb_people_infected = 0 and nb_people_exposed = 0) {
        do pause;
    }
}

species people skills: [moving] {
    bool is_infected <- false;
    bool is_exposed <- false;
    bool is_recovered <- false;
    bool is_immune <- false;
    bool is_dead <- false;
    int time_exposed <- 0;
    int time_infected <- 0;
    int time_recovered <- 0;
    int time_dead <- 0;
    int exposed_will_be_infected <- 0;
    int infected_will_recover_or_die <- 0;
    point target;
    int staying_counter;
```

```
int expose_counter <- 0;

reflex stay when: target = nil {
    staying_counter <- staying_counter + 1;
    if flip(staying_counter / staying_coeff) {
        if(is_infected and (cycle >= 1728)){ /* If infected and after day 07 (bc day 07 pa
        iimplement yung isolation) */
            if((cycle-time_infected >= 288) and (cycle-time_infected <= 4320)){ /* Quarantine for
            14 days or until recovered */
                target <- any_location_in (one_of(qbuilding));
            }else{
                target <- any_location_in(one_of(building));
            }
        }else{
            target <- any_location_in(one_of(building));
        }
    }
}

reflex move when: target != nil {
    do goto target: target on: road_network;
    if (location = target) {
        target <- nil;
        staying_counter <- 0;
    }

}

reflex expose when: is_infected {
    ask people at_distance expose_distance {
        if (is_dead){
            is_dead <- true;
        }else if (is_immune){
            is_recovered <- true;
            is_infected <- false;
            is_exposed <- false;
        }else if (is_infected){
            is_infected <- true;
            is_exposed <- false;
            is_recovered <- false;
        }else{
            expose_counter <- expose_counter + 1;
            if (expose_counter = 3){ /* Must be exposed for 3 cycles (15 mins) before to be
            considered as exposed */
                is_exposed <- true;
                is_infected <- false;
                is_recovered <- false;
```

```
                time_exposed <- cycle;
                exposed_will_be_infected <- rnd(1440,2880); /* exposed will be infected after
                    5-10 days */
            }
            if (cycle mod 288 = 0){ /* Reset everyday */
                expose_counter <- 0;
            }
        }
    }
}

reflex infect when: is_exposed {
    if(is_immune = false and is_recovered = false and is_dead = false){
        if ((cycle - time_exposed) >= exposed_will_be_infected) { /* will determine if infected
        after 3-10 days of being exposed */
            if flip(rnd(0.3,0.8)) {
                /* write "Infected"; */
                is_infected <- true;
                is_exposed <- false;
                is_recovered <- false;
                time_infected <- cycle;
                time_exposed <- 0;
                infected_will_recover_or_die <- rnd(2016,2880); /* will recover or die after
                7-10 days */
            }else{
                /* write "Not Infected"; */
                is_infected <- false;
                is_exposed <- false;
                is_recovered <- false;
                is_immune <- false;
                is_dead <- false;
                time_exposed <- 0;
                time_infected <- 0;
                expose_counter <- 0;
            }
        }
    }
}

reflex recover when: is_infected {
    if((cycle - time_infected) >= infected_will_recover_or_die){ /* if infected for 7-14 days */
        if flip(proba_recover){ /* If agent will recover */
            is_immune <- true;
            is_recovered <- true;
            is_infected <- false;
            is_exposed <- false;
            is_dead <- false;
```

```
                time_recovered <- cycle;
            }else{ /* Else, agent will be dead */
                is_dead <- true;
                is_recovered <- false;
                is_immune <- false;
                is_infected <- false;
                is_exposed <- false;
                time_dead <- cycle;
            }
        }
    }

    aspect circle {
        draw circle(1) color: is_exposed ? #orange : (is_infected ? #red : (is_recovered ? #pink :
        (is_dead ? #black : #blue)));
    }

    aspect sphere3D {
        draw sphere(2) at: {location.x, location.y, location.z + 2} color: is_exposed ? #orange :
        (is_infected ? #red : (is_recovered ? #pink : (is_dead ? #black : #blue)));
    }

}

species road {
    geometry display_shape <- shape + 2.0;
    aspect default {
        draw display_shape color: #black depth: 3.0;
    }
}

species building {
    int nb_infected <- 0 update: self.people_in_building count each.is_infected;
    int nb_exposed <- 0 update: self.people_in_building count each.is_exposed;
    int nb_recovered <- 0 update: self.people_in_building count each.is_recovered;
    int nb_dead <- 0 update: self.people_in_building count each.is_dead;
    int nb_total <- 0 update: length(self.people_in_building);
    float height <- rnd(10 #m, 20 #m);

    species people_in_building parent: people schedules: [] {
    }

    reflex let_people_leave {
        ask people_in_building {
            staying_counter <- staying_counter + 1;
        }
```

```
        release people_in_building where (flip(each.staying_counter / staying_coeff)) as: people
        in: world {
            if(is_infected and (cycle >= 1728)){ /* In infected and after day 07 (bc day 07 pa
            iimplement yung isolation) */
                if((cycle-time_infected >= 288) and (cycle-time_infected <= 4320)){ /* Quarantine for
                14 days or until recovered */
                    target <- any_location_in (one_of(qbuilding));
                }else{
                    target <- any_location_in(one_of(building));
                }
            }else{
                target <- any_location_in(one_of(building));
            }
        }

    }

    reflex let_people_enter {
        capture (people inside self where (each.target = nil)) as: people_in_building;
    }

    aspect default {
        draw shape color: nb_total = 0 ? #gray : (float(nb_infected) / nb_total > 0.5 ? #red : #green)
        border: #black depth: height;
    }
}

species qbuilding{
    float height <- rnd(10 #m, 20 #m);

    aspect default {
        draw shape color: #pink border: #black depth: height;
    }
}

experiment main_experiment type: gui { /* experiment with a graphical interface */
    parameter "Initial Population" var: nb_people;
    parameter "Exposure distance" var: expose_distance;
    /* parameter "Proba infection" var: proba_infection min: 0.0 max: 1.0; */
    parameter "Nb people infected at init" var: nb_infected_init;
    output {
        monitor "Day" value: current_day;
        monitor "Total Population" value: nb_people;
        monitor "Number of Susceptible" value: nb_people_susceptible;
        monitor "Number of Exposed" value: nb_people_exposed;
        monitor "Number of Infected" value: nb_people_infected;
        monitor "Number of Recovered" value: nb_people_recovered;
```

```
        monitor "Number of Dead" value: nb_people_dead;
        monitor "Current hour" value: current_date.hour;
        monitor "Current minute" value: current_date.minute;
        monitor "Infected people rate" value: infected_rate;

        display view3D type: opengl antialias: false {
            light #ambient intensity: 20;
            light #default intensity:(is_night ? 127 : 255); /*  intensity of the light to 127 during
                the night, and 255 for the day */
            /* image "../includes/soil.jpg" refresh: false;  */
            species road;
            species people aspect: sphere3D;
            species building transparency: 0.3;
            species qbuilding transparency: 0.3;
        }

        display chart_display refresh: every(10 #cycles) {
            chart "Disease spreading" type: series {
                data "susceptible" value: nb_people_susceptible color: #blue marker: false;
                data "exposed" value: nb_people_exposed color: #orange marker: false;
                data "infected" value: nb_people_infected color: #red marker: false;
                data "recovered" value: nb_people_recovered color: #pink marker: false;
                data "dead" value: nb_people_dead color: #black marker: false;
            }
        }
    }

}

/* Code by Lyka Raquel C. Lim */
```

Appendix O

Code for Scenario 04

```
model Scenario04

global {
    int nb_people <- 4000 update: 4000 - nb_people_dead;
    float agent_speed <- 5.0 #km / #h;
    float step <- 5 #minutes;
    float expose_distance <- 2.0 #m;
    float proba_infection <- 0.50;
    float proba_recover <- 0.80; /* 80% chance of recovering */
    int nb_infected_init <- 5;
    int nb_exposed_init <- 0;
    int nb_recovered_init <- 0;
    int nb_immune_init <- 0; /* immune only if already recovered */
    int nb_dead_init <- 0;
    file roads_shapefile <- file("../includes/road.shp");
    file buildings_shapefile <- file("../includes/NonQ_building.shp");
    file qbuildings_shapefile <- file("../includes/Q_building.shp");
    geometry shape <- envelope(buildings_shapefile);
    graph road_network;
    /* Makulit at hours: 9-11am, 3-6pm. At these times, agent has a more chance to leave the building*/
    float staying_coeff update: 10.0 ^ (1 + min([abs(current_date.hour - 9), abs(current_date.hour - 10),
        abs(current_date.hour - 11), abs(current_date.hour - 15), abs(current_date.hour - 16),
        abs(current_date.hour - 17), abs(current_date.hour - 18)]));
    list<people_in_building> list_people_in_buildings update: (building accumulate each.people_in_building);
    int nb_people_susceptible <- nb_people - nb_infected_init update: (nb_people - nb_people_infected -
        nb_people_recovered);
    int nb_people_infected <- nb_infected_init update: (people + list_people_in_buildings) count
        (each.is_infected);
    int nb_people_not_infected <- nb_people - nb_infected_init update: (nb_people - nb_people_infected);
    int nb_people_exposed <- nb_exposed_init update: (people + list_people_in_buildings) count
        (each.is_exposed);
    int nb_people_not_exposed <- nb_people - nb_exposed_init update: (nb_people - nb_people_exposed);
    int nb_people_recovered <- nb_recovered_init update: (people + list_people_in_buildings) count
        (each.is_recovered);
    int nb_people_not_recovered <- nb_people - nb_recovered_init update: (nb_people - nb_people_recovered);
    int nb_people_immune <- nb_immune_init update: (people + list_people_in_buildings) count
        (each.is_immune);
    int nb_people_not_immune <- nb_people - nb_immune_init update: (nb_people - nb_people_immune);
```

```
    int nb_people_dead <- nb_dead_init update: (people + list_people_in_buildings) count (each.is_dead);
    int nb_people_not_dead <- nb_people - nb_dead_init update: (nb_people - nb_people_dead);
    int current_day <- 1 update: current_date.hour = 0 and current_date.minute = 0 ? current_day +
        1 : current_day;
    /* night is before 7am and after 8pm */
    bool is_night <- true update: current_date.hour < 7 or current_date.hour > 20;
    bool lockdown <- true update: (current_day > 6 and current_day < 21) or (current_day > 36 and
        current_day < 51) or (current_day > 66 and current_day < 81) or (current_day > 96 and
        current_day < 111) or (current_day > 126 and current_day < 141) or (current_day > 156 and
        current_day < 171); /* lockdown every 2nd and 3rd week of the month */
    float infected_rate update: nb_people_infected / nb_people;


    init {
        create road from: roads_shapefile;
        road_network <- as_edge_graph(road);
        create building from: buildings_shapefile;
        create qbuilding from: qbuildings_shapefile;
        create people number: nb_people {
            speed <- agent_speed;
            building bd <- one_of(building);
            location <- any_location_in(bd);
        }

        ask nb_infected_init among people {
            is_infected <- true;
            time_infected <- 0;
            infected_will_recover_or_die <- rnd(2016,2880); /* will recover or die after 7-10 days */
            /* write "Infected at: " + time_infected + ", will recover at " + infected_will_recover_or_die; */
        }
    }

    reflex end_simulation when: infected_rate = 1.0 or (nb_people_infected = 0 and nb_people_exposed = 0) {
        do pause;
    }
}

species people skills: [moving] {
    bool is_infected <- false;
    bool is_exposed <- false;
    bool is_recovered <- false;
    bool is_immune <- false;
    bool is_dead <- false;
    int time_exposed <- 0;
    int time_infected <- 0;
    int time_recovered <- 0;
    int time_dead <- 0;
```

```
int exposed_will_be_infected <- 0;
int infected_will_recover_or_die <- 0;
point target;
int staying_counter;
int expose_counter <- 0;

reflex lockdown when: lockdown {
    target <- nil;
    staying_counter <- 0;
    if flip(staying_counter / staying_coeff) { /* If mababa percentage, no new target */
        target <- any_location_in (one_of(building));
    }
}

reflex stay when: target = nil {
    if(not lockdown){
        staying_counter <- staying_counter + 1;
        if flip(staying_counter / staying_coeff) {
            if(is_infected and (cycle >= 1728)){ /* If infected and after day 07 (bc day 07 pa
            iimplement yung isolation) */
                if((cycle-time_infected >= 288) and (cycle-time_infected <= 4320)){ /* Quarantine
                for 14 days or until recovered */
                    target <- any_location_in (one_of(qbuilding));
                }else{
                    target <- any_location_in(one_of(building));
                }
            }else{
                target <- any_location_in(one_of(building));
            }
        }
    }else{
        if(is_infected and (cycle >= 1728)){ /* If infected and after day 07 (bc day 07 pa iimplement
        yung isolation) */
            if((cycle-time_infected >= 288) and (cycle-time_infected <= 4320)){ /* Quarantine for 14
            days or until recovered */
                target <- any_location_in (one_of(qbuilding));
            }
        }else if (is_recovered or is_dead){
            target <- any_location_in(one_of(building));
        }
    }
}

reflex move when: target != nil {
    do goto target: target on: road_network;
    if (location = target) {
        target <- nil;
```

```
        staying_counter <- 0;
    }

}

reflex expose when: is_infected {
    ask people at_distance expose_distance {
        if (is_dead){
            is_dead <- true;
        }else if (is_immune){
            is_recovered <- true;
            is_infected <- false;
            is_exposed <- false;
        }else if (is_infected){
            is_infected <- true;
            is_exposed <- false;
            is_recovered <- false;
        }else{
            expose_counter <- expose_counter + 1;
            if (expose_counter = 3){ /* Must be exposed for 3 cycles (15 mins) before to be
            considered as exposed */
                is_exposed <- true;
                is_infected <- false;
                is_recovered <- false;
                time_exposed <- cycle;
                exposed_will_be_infected <- rnd(1440,2880); /* exposed will be infected after
                5-10 days */
            }
            if (cycle mod 288 = 0){ /* Reset everyday */
                expose_counter <- 0;
            }
        }
    }
}

reflex infect when: is_exposed {
    if(is_immune = false and is_recovered = false and is_dead = false){
        if ((cycle - time_exposed) >= exposed_will_be_infected) { /* will determine if infected
        after 3-10 days of being exposed */
            if flip(rnd(0.3,0.8)) {
                /* write "Infected"; */
                is_infected <- true;
                is_exposed <- false;
                is_recovered <- false;
                time_infected <- cycle;
                time_exposed <- 0;
                infected_will_recover_or_die <- rnd(2016,2880); /* will recover or die after
```

```
                7-10 days */
            }else{
                /* write "Not Infected"; */
                is_infected <- false;
                is_exposed <- false;
                is_recovered <- false;
                is_immune <- false;
                is_dead <- false;
                time_exposed <- 0;
                time_infected <- 0;
                expose_counter <- 0;
            }
        }
    }
}

reflex recover when: is_infected {
    if((cycle - time_infected) >= infected_will_recover_or_die){ /* if infected for 7-14 days */
        if flip(proba_recover){ /* If agent will recover */
            is_immune <- true;
            is_recovered <- true;
            is_infected <- false;
            is_exposed <- false;
            is_dead <- false;
            time_recovered <- cycle;
        }else{ /* Else, agent will be dead */
            is_dead <- true;
            is_recovered <- false;
            is_immune <- false;
            is_infected <- false;
            is_exposed <- false;
            time_dead <- cycle;
        }
    }
}

aspect circle {
    draw circle(1) color: is_exposed ? #orange : (is_infected ? #red : (is_recovered ? #pink :
    (is_dead ? #black : #blue)));
}

aspect sphere3D {
    draw sphere(2) at: {location.x, location.y, location.z + 2} color: is_exposed ? #orange :
    (is_infected ? #red : (is_recovered ? #pink : (is_dead ? #black : #blue)));
}

}
```

```
species road {
    geometry display_shape <- shape + 2.0;
    aspect default {
        draw display_shape color: #black depth: 3.0;
    }
}

species building {
    int nb_infected <- 0 update: self.people_in_building count each.is_infected;
    int nb_exposed <- 0 update: self.people_in_building count each.is_exposed;
    int nb_recovered <- 0 update: self.people_in_building count each.is_recovered;
    int nb_dead <- 0 update: self.people_in_building count each.is_dead;
    int nb_total <- 0 update: length(self.people_in_building);
    float height <- rnd(10 #m, 20 #m);

    species people_in_building parent: people schedules: [] {
    }

    reflex let_people_leave {
        ask people_in_building {
            staying_counter <- staying_counter + 1;
        }

        release people_in_building where (flip(each.staying_counter / staying_coeff)) as: people
        in: world {
            if(is_infected and (cycle >= 2016)){ /* In infected and after day 07 (bc day 07 pa
            iimplement yung isolation) */
                if((cycle-time_infected >= 288) and (cycle-time_infected <= 4320)){ /* Quarantine for
                14 days or until recovered */
                    target <- any_location_in (one_of(qbuilding));
                }else{
                    target <- any_location_in(one_of(building));
                }
            }else{
                target <- any_location_in(one_of(building));
            }
        }

    }

    reflex let_people_enter {
        capture (people inside self where (each.target = nil)) as: people_in_building;
    }

    aspect default {
        draw shape color: nb_total = 0 ? #gray : (float(nb_infected) / nb_total > 0.5 ? #red : #green)
```

```
        border: #black depth: height;
    }
}

species qbuilding{
    float height <- rnd(10 #m, 20 #m);

    aspect default {
        draw shape color: #pink border: #black depth: height;
    }
}

experiment main_experiment type: gui { /* experiment with a graphical interface */
    parameter "Initial Population" var: nb_people;
    parameter "Exposure distance" var: expose_distance;
    /* parameter "Proba infection" var: proba_infection min: 0.0 max: 1.0; */
    parameter "Nb people infected at init" var: nb_infected_init;
    output {
        monitor "Day" value: current_day;
        monitor "Total Population" value: nb_people;
        monitor "Number of Susceptible" value: nb_people_susceptible;
        monitor "Number of Exposed" value: nb_people_exposed;
        monitor "Number of Infected" value: nb_people_infected;
        monitor "Number of Recovered" value: nb_people_recovered;
        monitor "Number of Dead" value: nb_people_dead;
        monitor "Current hour" value: current_date.hour;
        monitor "Current minute" value: current_date.minute;
        monitor "Infected people rate" value: infected_rate;

        display view3D type: opengl antialias: false {
            light #ambient intensity: 20;
            light #default intensity:(is_night ? 127 : 255); /*  intensity of the light to 127 during
                the night, and 255 for the day */
            /* image "../includes/soil.jpg" refresh: false;  */
            species road;
            species people aspect: sphere3D;
            species building transparency: 0.3;
            species qbuilding transparency: 0.3;
        }

        display chart_display refresh: every(10 #cycles) {
            chart "Disease spreading" type: series {
                data "susceptible" value: nb_people_susceptible color: #blue marker: false;
                data "exposed" value: nb_people_exposed color: #orange marker: false;
                data "infected" value: nb_people_infected color: #red marker: false;
                data "recovered" value: nb_people_recovered color: #pink marker: false;
                data "dead" value: nb_people_dead color: #black marker: false;
```

```
            }
        }
    }

}

/* Code by Lyka Raquel C. Lim */
```