Herd Immunity Project Report

The main aim of Disease simulation project is to model the spread of a disease through a single population, taking factors called susceptible, infectious, recovered and vaccination. This report summarizes the results of the simulation under simulation parameters.

The following are simulation parameters :
Population size:15000
Duration/Number of days: 10
Transmissiability : 0.1
Vaccination rate : 0 - 1
Number of Contacts : 5

Initially, the project starts by creating a disease with an infection rate or Transmissiability rate 0.1. The information provided entails applying particular formulas and starting conditions to determine the proportion of susceptible and immunized individuals in a population.

The Zeroth Day's Initial Conditions :

Applying the starting circumstances :

$$\text{Vaccination\_Count} = \text{m\_size} * \text{m\_vaccinationRate}$$

m_size: Size of the total population.
m_vaccinationRate: The percentage of people who receive vaccinations.
Vaccination_Count = 15000 * 0.1 = 1500

$$\text{Susceptible\_Count} = \text{m\_size} - (\text{m\_size} * \text{m\_vaccinationRate})$$

Susceptible_count = 15000 - (15000 * 0.1) = 13500

Total Population:

13500 vulnerable individuals + 1500 vaccinated individuals = 15000 people.

First Vulnerable Individuals that is 13500 individuals are at a risk for the illness (have not received vaccinations).1500 people have received vaccinations as the Initial Vaccinated Persons.This for understanding of how the population's health state changes over time, especially with regard to the influence of vaccination rates on disease spread, these computations and initial values are essential.

Afterward, a random susceptible person is infected on the first day and he is spreading the disease to different persons with the limit of population size 15000. He then comes into contact with 5 random people. Based on the infection rate and health status of a person, the disease will spread. Then the process will continue. Each infectious person will become a recovered person after 5 days. The simulation ends when no more infectious people will left.

In concluding , Each day it will print the number of susceptible, infectious, Vaccinated and recovered persons.

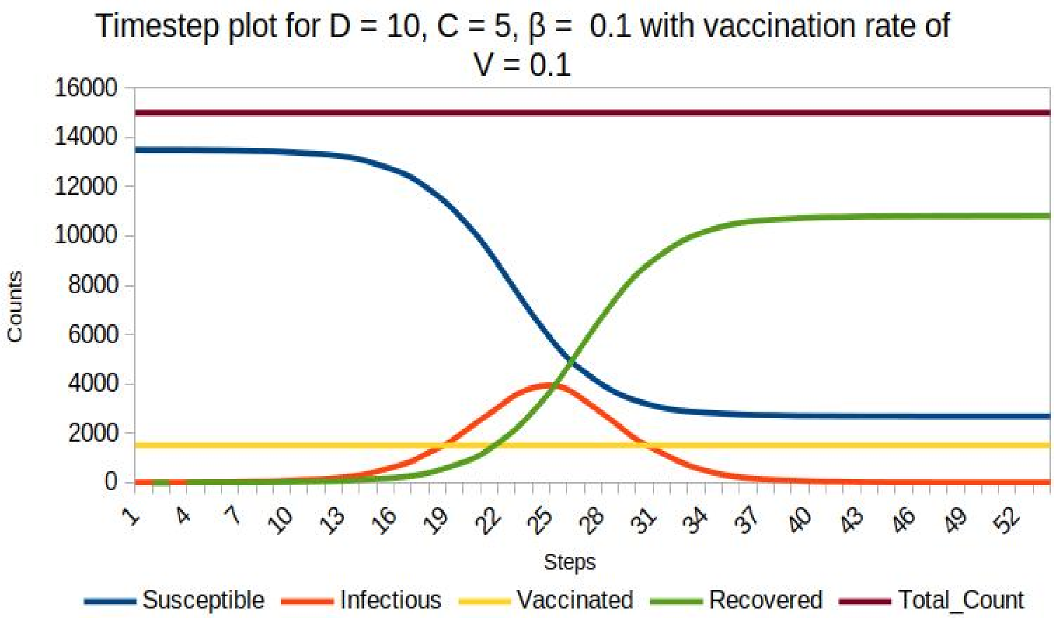

Figure 1

To determine the fundamental reproduction number R0, i attempt to plot various vaccination rates from the graph shown in Figure 1.Figure 2 illustrates the number of recovered individuals based on various vaccination rates. The figure 2 is shown below.

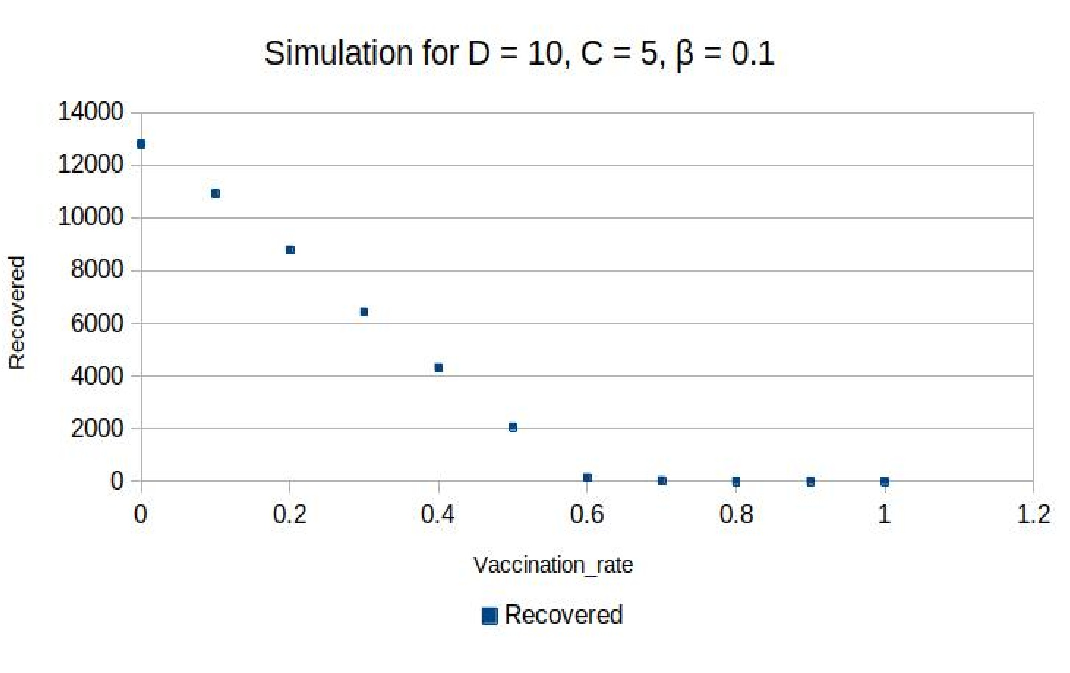

Figure 2

To calculate the R0 (Basic reproduction number),we need the parameters called duration of disease (D), Transmissiability (β) and the number of contacts (C).

$$R0=D * \beta * C$$

According to my parameters,

$D = 10$, $\beta = 0.1$, $C = 5$

Hence $R0 = 5$

Based on the HIT(Herd Immunity Threshold) reference graph and my R0, it should be 80%. But,when the vaccination rate reaches at 0.6 ,the disease is eradicated as shown in figure 2.Even though some of the susceptible person are there,spreading of disease is stopped. But,it doesn't match with the herd immunity threshold. The difference between the simulation results and the theoretical herd immunity threshold (HIT) happens because the theoretical model makes some basic assumptions that may not match the real-world dynamics in the simulation. The Herd immunity threshold vs Basic reproduction number, assumes that the population is evenly mixed, everyone has the same chance of spreading the disease, and vaccinations are given randomly. However, the simulation likely includes more realistic factors, such as variations in how people interact, targeted vaccinations for certain groups, or random events that can change the spread of the disease.

For example, if the simulation reduces the effective R0, due to changes in contact patterns or behaviors, the disease can be controlled with fewer vaccinations. Similarly, if vaccinations are focused on people who are most likely to spread the disease, this can stop the outbreak faster. Random fluctuations in smaller populations can also play a role. Because of these factors, the disease in my simulation is eradicated at a vaccination rate of 0.6 instead of vaccination rate of 0.8 for R0 = 5 .

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