SS 2025

DISEASE SIMULATION REPORT

SUBJECT: Programming Lab

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1. Introduction

One of the most effective strategies for controlling infectious diseases is vaccination. The concept of herd immunity suggests that if a sufficient portion of the population is immune, the spread of the disease can be significantly reduced or even stopped. This report explores the effect of varying vaccination rates on disease progression using an agent-based simulation model.

The goal is to determine the relationship between vaccination rate and final disease outcome in a simulated population of 30,000 individuals, using a configurable disease model with adjustable transmission probability and infection duration.

2. Methodology

We implemented a simulation using C++, modeling a single population of 30,000 individuals. Each person can be in one of four health states: susceptible, infected, recovered, or vaccinated.

Simulation Parameters:

- Population size: 30,000
- Vaccination rates: 0% to 100% in 10% increments
- Disease duration: days d (e.g., 2)
- Transmission probability: p (e.g., 0.2)
- Simulation steps: until all infected recover or no new further infections occur

For each vaccination rate, we:

- Initialize the population
- Infect a single patient zero
- Run the simulation while tracking state changes
- Record the total number of recovered individuals at the end

We got this as an output,

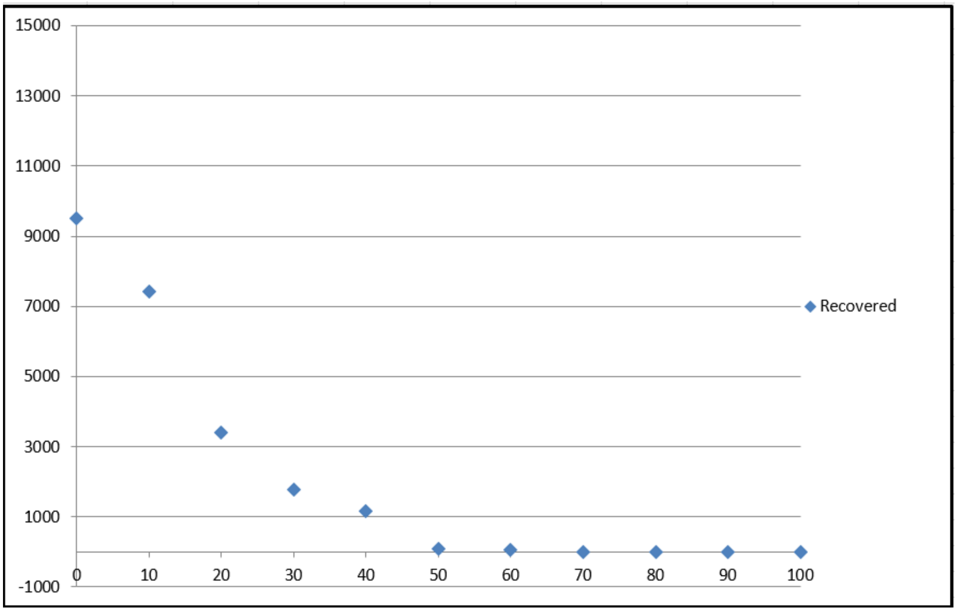

Figure 1: Plot of Vaccination rate (in %) & No. of recovered people

$$D = 2, C = 6, \beta = 0.2$$

Whereas, duration(D) = 2 , Transmissibility(ß) = 0.2 , No of Contacts(C) = 6

So, Value of basic reproduction number is

Ro = D * ß *C = 2 * 0.2 * 6 = 2.4

3. Results

Recovered People vs. Vaccination Rate

For Ro = 2.4, herd immunity should have been achieved by having the vaccination rate of almost 58% as mentioned in fig 3 of requirements document.However, in this simulation, I have been able to achieve herd immunity with vaccination rate = 50%.

4. Discussion

In the simulation, transmissibility is set to 0.2, meaning 1.2 out of 6 contacts should be infected per interaction. However, we neglect the decimal part and only 1 person is infected instead of potentially 2 some of the time.

This underestimates early infections, leading to fewer recovered individuals early in the simulation. As a result, more people remain susceptible for longer, allowing the disease to keep spreading.

Therefore, herd immunity is achieved much earlier (around 50%) than it ideally could have been if the decimal part of transmissibility were considered.

Another criteria is the duration of sickness (D = 2). This duration is too short for this transmissibility (0.2) which is why we get the plot below:

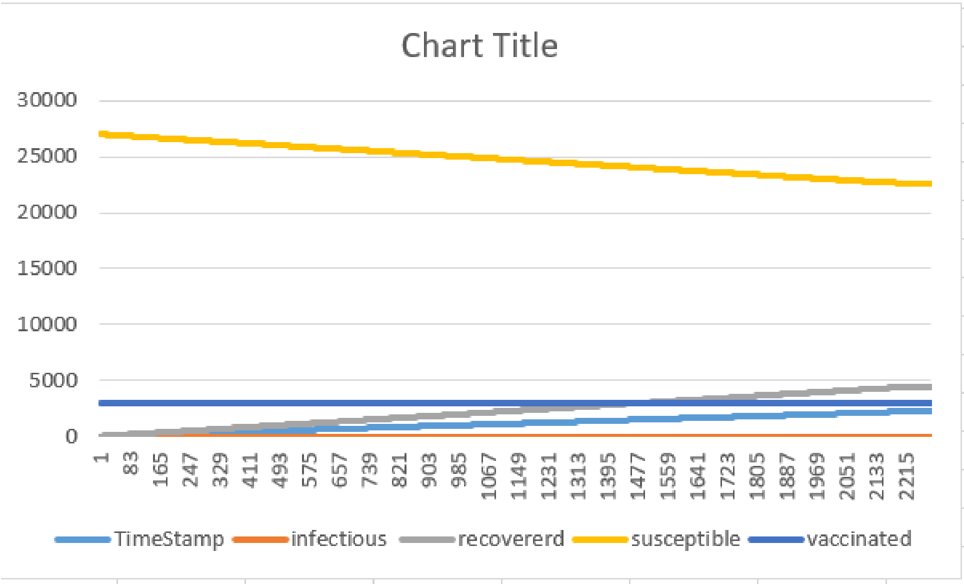

Figure 2: Timestep plot for D = 2,C = 6,β = 0.1 with vaccination rate of V = 0.1.

The plot shows that recovered list keeps increasing, the susceptible list keeps decreasing, whereas the vaccinated and infectious list remain constant for the population size = 30,000.

5. Conclusion

The simulation effectively demonstrates how vaccination reduces disease spread. A threshold near 60% vaccination rate aligns with herd immunity expectations. This supports public health strategies that aim to vaccinate a sufficient fraction of the population to control outbreaks.

Future work can extend the model to multiple populations, age groups, and variable mobility to improve realism.