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COE 322 (14615)

Disease Simulation Project Writeup

Purpose and Introduction

In this project, I am using C++ and Linux to simulate the spread of a disease through a population. I am taking different variables into account such as population size, what percentage of the population is vaccinated, and the probability the disease is transmitted on contact. I will use these variables to simulate the total amount of days it takes for the disease to run through the population, how many people catch the disease, and the amount of unvaccinated people that are never infected.

Each person has a status based on vaccination, infection, susceptibility, and recovery. The program makes the assumption that a person that is vaccinated cannot get sick with the disease, a person that has recovered from the disease cannot get the disease again, and there are a fixed amount of days that it takes each person to get over the disease.

General Results

The simulation produces results as follows. The values for probability of transmission and population vaccinated are displayed in Tables 1-5. Tables 1-5 use a population of 500 and take 10 population samples for each unique probability of transmission and percentage of population vaccinated.

<u>Table1:</u> Probability of transmission = 0.5, Population vaccinated = 0.5

Total Infected	Never Infected	Length (day)
231	19	24
240	10	24
234	16	23
239	11	22
235	15	23
233	17	23
242	8	23
240	10	20
242	8	22
231	19	21

Table 1 displays the total number of people infected, total number of people not infected, and how long it takes for the disease to run through the population when probability of transmission = 50% and percent of population vaccinated = 50%. Generally, the number of people that are infected is about half of the population (about 237), the number of people that are never infected is about 13, and the average time it takes for the disease to run through the population is 23 days.

Table 2: Probability of transmission = 0.2, Population vaccinated = 0.2

Total Infected	Never Infected	Length (day)
332	68	35
329	71	30
316	84	40
337	63	34
339	61	38
305	95	32
314	86	40
340	60	32
299	101	33
327	73	36

Table 2 displays the total number of people infected, total number of people not infected, and how long it takes for the disease to run through the population when probability of transmission = 20% and percent of population vaccinated = 20%. Generally, the number of people that are infected is about 324, the number of people that are never infected is about 76, and the average time it takes for the disease to run through the population is 35 days.

<u>Table 3:</u> Probability of transmission = 0.8, Population vaccinated = 0.8

Total Infected	Never Infected	Length (day)
84	16	22
88	12	30
84	16	22
78	22	23
79	21	24
87	13	27
89	11	22
81	19	31
83	17	24
86	14	30

Table 3 displays the total number of people infected, total number of people not infected, and how long it takes for the disease to run through the population when probability of transmission = 80% and percent of population vaccinated = 80%. Generally, the number of people that are infected is about 84, the number of people that are never infected is about 16, and the average time it takes for the disease to run through the population is 26 days.

<u>Table 4:</u> Probability of transmission = 0.2, Population vaccinated = 0.8

Total Infected	Never Infected	Length (day)
1	99	5
2	98	8
2	98	6
1	99	5
2	98	8
1	99	5
2	98	6
1	99	5
1	99	5
1	99	5

Table 4 displays the total number of people infected, total number of people not infected, and how long it takes for the disease to run through the population when probability of transmission = 20% and percent of population vaccinated = 80%. Generally, the number of people that are infected is about 1, the number of people that are never infected is about 99, and the average time it takes for the disease to run through the population is 6 days.

Table 5: Probability of transmission = 0.8, Population vaccinated = 0.2

Total Infected	Never Infected	Length (day)
400	0	12
400	0	12
400	0	12
400	0	10
400	0	13
400	0	15
400	0	12
400	0	12
400	0	12
400	0	14

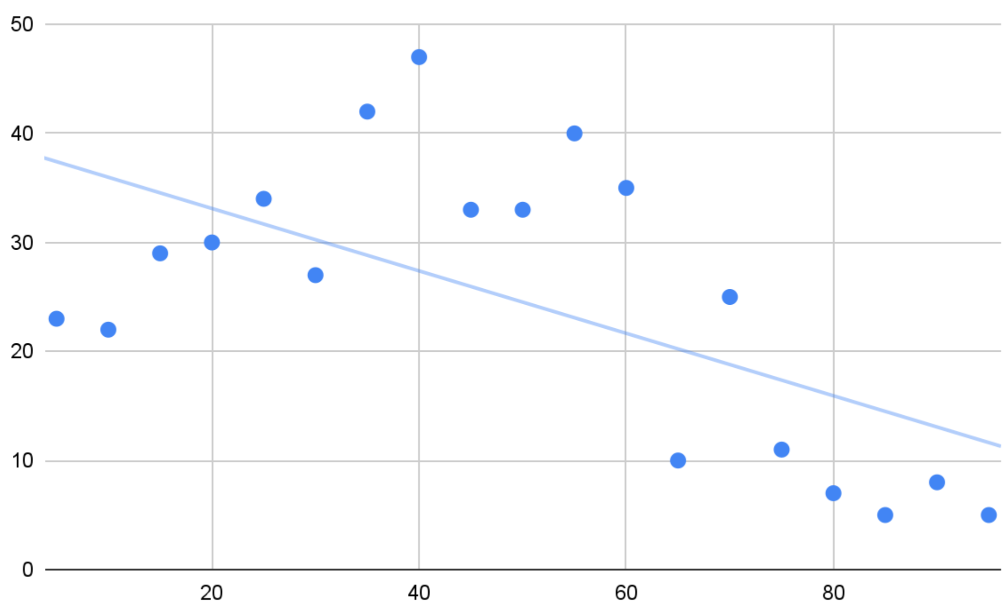
Table 5 displays the total number of people infected, total number of people not infected, and how long it takes for the disease to run through the population when probability of transmission = 80% and percent of population vaccinated = 20%. Generally, the number of people that are infected is 400, the number of people that are never infected is 0, and the average time it takes for the disease to run through the population is 12 days.

Based on Tables 1-5, when the probability of transmission is low and the percentage of the population that is vaccinated is low, many people are infected (due to low vaccination) and many people also do not get sick (due to low transmission). When the probability of transmission is low and the percentage of the population that is vaccinated is high, barely anyone gets sick and the disease runs through the population quickly. When the probability of transmission is high and the percentage of the population that is vaccinated is high, not many people are infected and not many people get the disease (due to low vaccination). When the probability of transmission is high and the percentage of the population that is vaccinated is low, almost everyone that is susceptible gets infected and nobody does not get infected. When the probability of transmission is 50% and the percentage of the population that is vaccinated is 50%, about half the population gets sick and a low number of people never get infected.

Herd Immunity

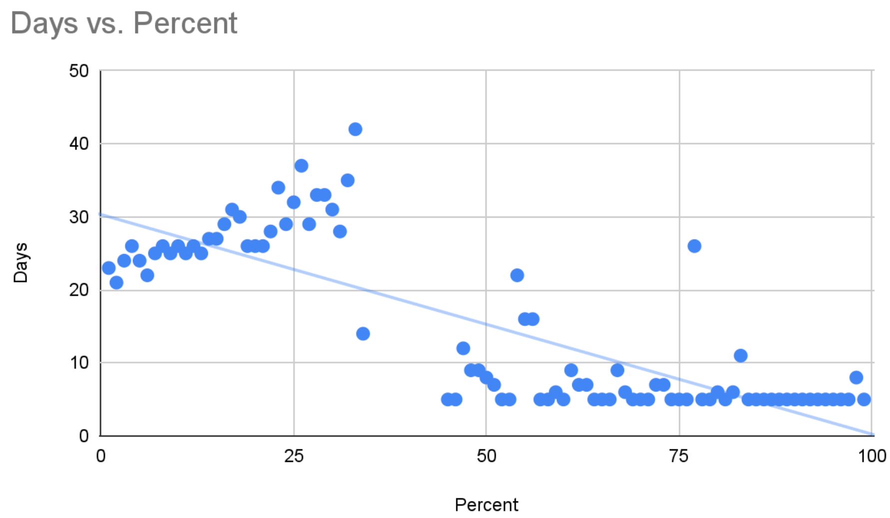
For the analysis on herd immunity, I used a population of 500 people and based the probability that the disease is transmitted on contact on the common flu. I determined a reasonable probability is 25%, meaning that when one person comes in contact with another, there is a 25% chance that the infected person will transmit the disease to the person that is susceptible. Each person takes 5 days to recover from the sickness, and each person comes into contact with 6 people each day. Herd immunity is achieved when enough of the population is vaccinated so that 95% of unvaccinated individuals are never infected with the disease.

Graph 1:



Graph 1 illustrates the number of days it takes for the disease to run through the population as a function of the percentage of the population that is vaccinated. 19 data points were taken starting from 5% and increasing by 5 to 95%.

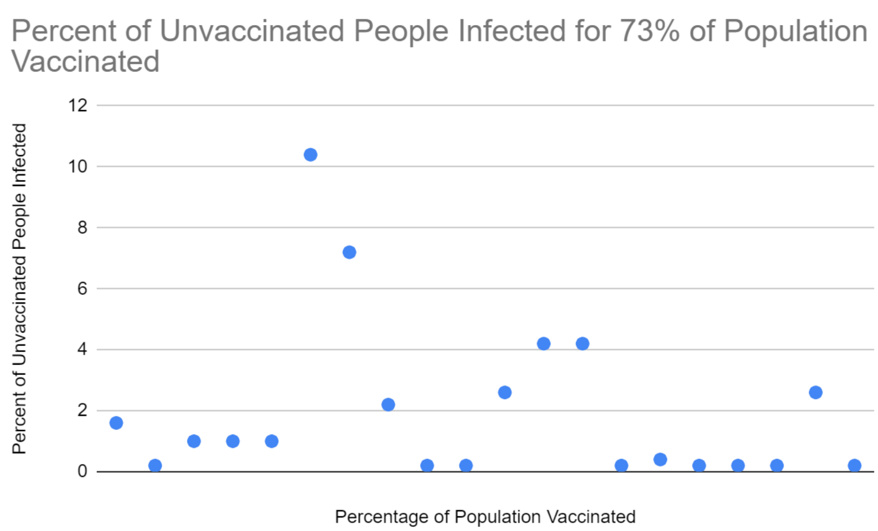
Graph 2:



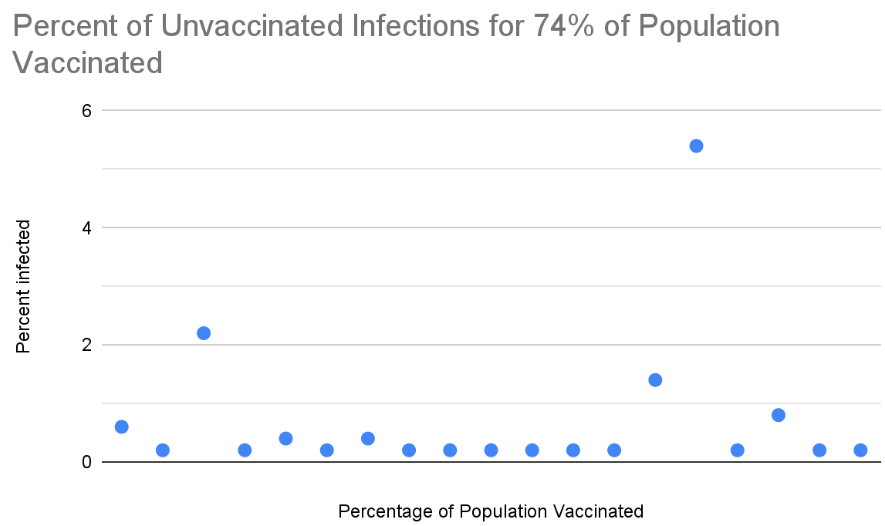
Graph 2 also illustrates the number of days it takes for the disease to run through the population as a function of the percentage of the population that is vaccinated. 99 data points were taken starting from 1% and increasing by 1 to 99%.

Based on Graph 1 and Graph 2, the number of days it takes for the disease to run through the population stays pretty steady and increases a little bit as the percentage of people vaccinated increases to 30-40%. Then, the number of days it takes for the disease to run through the population decreases as the percentage of people increases up to 90% (Graph 1) and 99% (Graph 2).

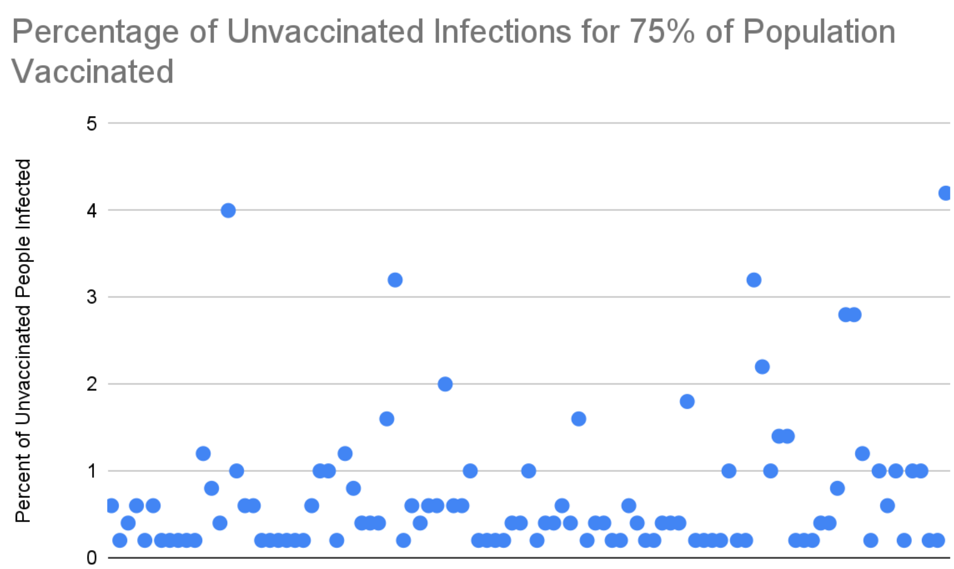
<u>Graph 3:</u>



Graph 4:



Graph 5:



Herd immunity was determined from Graphs 3, 4, and 5. In Graph 3 and Graph 4, I took 20 data points to determine if the percentage of unvaccinated infections exceeded 5% for 73% and 74% of the population vaccinated. In the first 20 points for 73%, two of the points were greater than 5%, and for 74%, one of the points was greater than 5%. In looking at 100 data points for a population that is 75% vaccinated, none of the unvaccinated infected population exceeded 5%. I determined that for a population of 500 with the probability of transmission of 25%, 75% of the population needs to be vaccinated for the population to achieve herd immunity.