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COE 322: C++ Final Project

Abstract:

The purpose of this experiment was to examine the propagation of a specific contagion and to investigate the concept of "herd immunity," a natural phenomenon that allows non-inoculated subjects to be "probabilistically immune" if a high enough percentage of the entire population is inoculated. The mechanics of the population and contagion were designed in C++ and the graphing/data analysis were done with R.

Experiments:

This study dives into four separate experiments. The first of which was a measure of the disease lifespan as a function of the initial inoculation percentage.

The second experiment was a set of trials that each vary a separate variable and again trace the infected population over time. The variables modified were the transmission probability and the number of interactions per day.

The third experiment examines "herd immunity" by varying the initial inoculation percentage and measuring the number of "untouched" (never infected) individuals in the population.

Data:

Experiment One: Disease propagation as a function of time

(n = 100, p = 0.5, duration = 3, interactions = 4)

Initial Inoculation (%)	0.05	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50
Disease Duration (days)	13	12	14	15	12	14	16	19	15	12

Experiment Two: Number of infected as a function of time

Trial #1: (n = 100, p = 0.5, duration = 3, interactions = 4, inoculation = 0.4)

T (days)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
# infected	1	1	1	1	2	4	5	6	13	22	24	15	7	4	2	1	1	1	0

Trial #2: (n = 100, p = 0.5, duration = 3, interactions = 10, inoculation = 0.4)

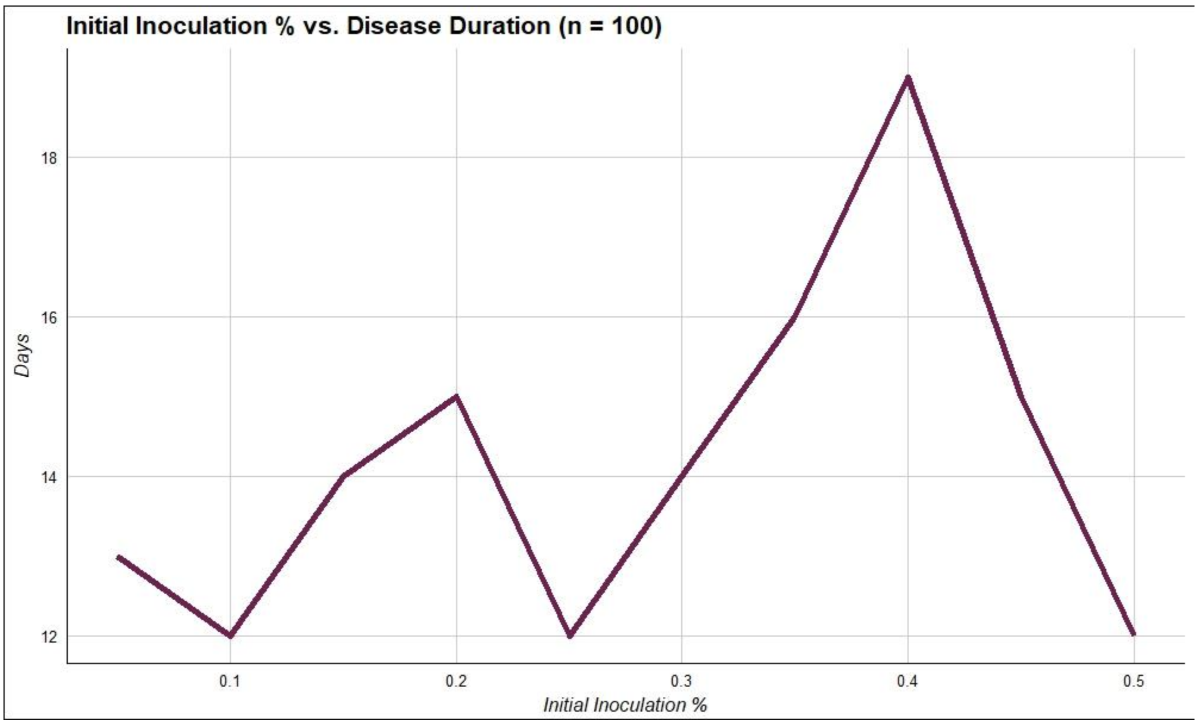
T (days)	1	2	3	4	5	6	7	8	9	10
# infected	1	1	2	7	24	43	42	9	2	0

Trial #3: (n = 100, p = 0.5, duration = 10, interactions = 4, inoculation = 0.4)

T (days)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
# infected	1	1	1	2	5	8	18	38	48	57	57	59	58	55	52	42	22	12	3	2	0

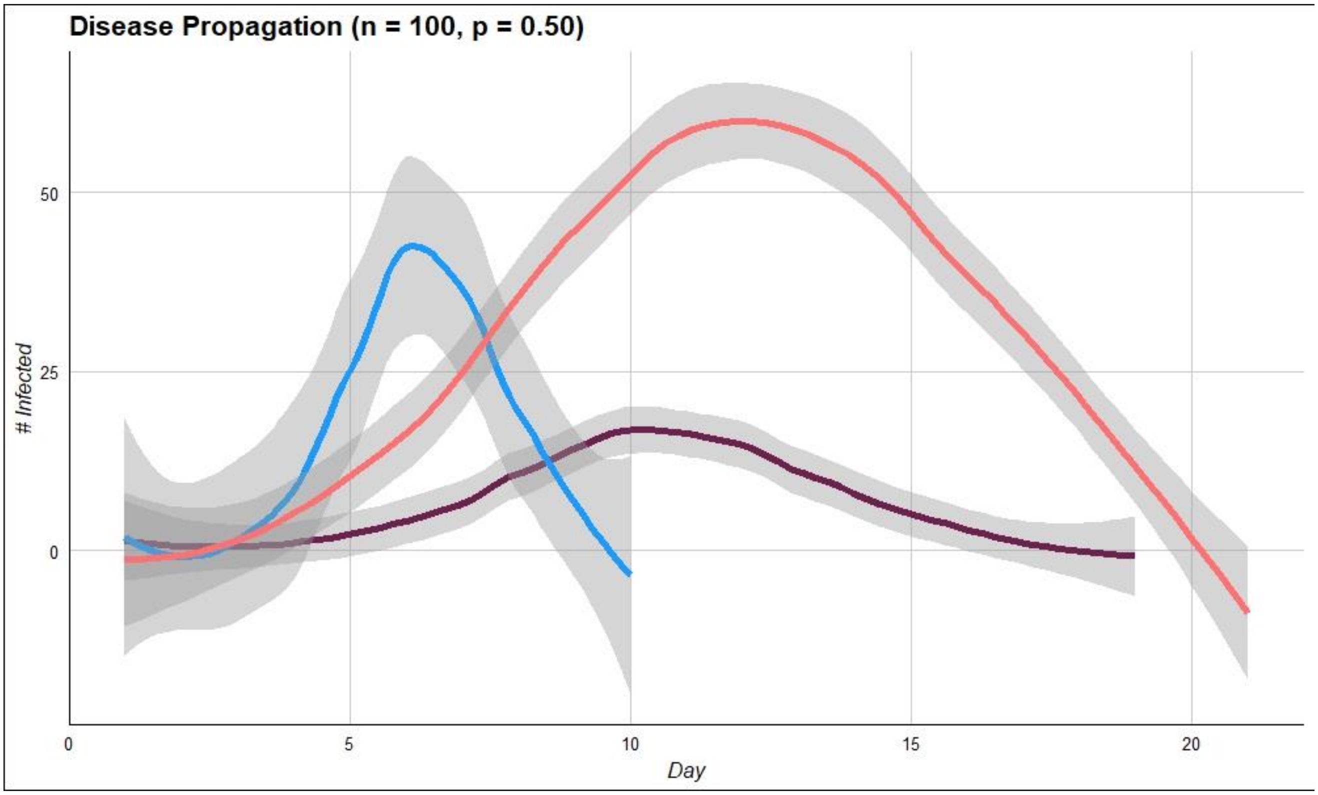
Experiment Three: Number of Untouched Individuals as a function of Inoculation

Initial Inoculation (%)	**Untouched Individuals**
0.05	3
0.10	2
0.15	2
0.20	4
0.25	3
0.30	2
0.35	2
0.40	5
0.45	9
0.50	12
0.55	13
0.60	29
0.65	25
0.70	22
0.75	22
0.80	19
0.85	13
0.90	9



Graphs:

Figure 01: Initial Inoculation (%) vs. Disease Duration



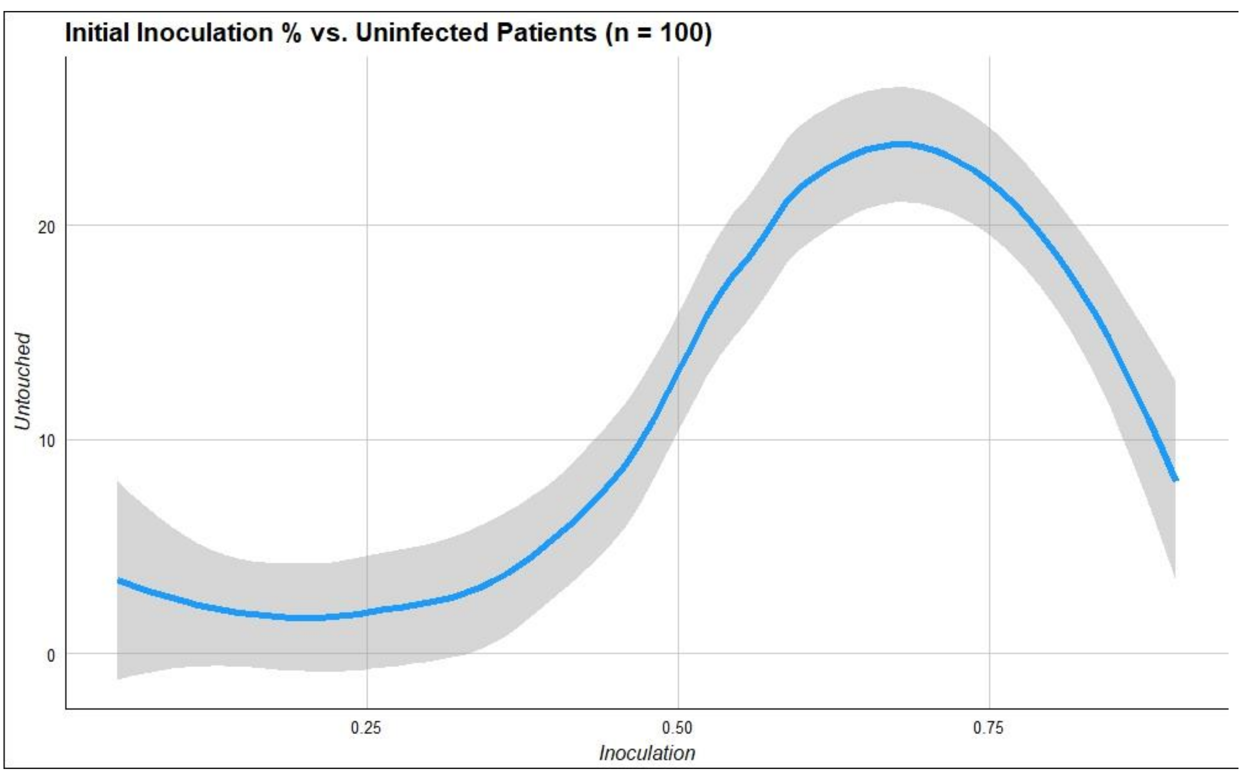


Figure 02: Trial #1 (purple), Trial #2 (blue), Trial #3 (red)

Figure 03: Initial Inoculation (%) vs. Number of Uninfected Individuals

Conclusion:

The above experiments presented a variety of interesting findings that help identify specific relationships between the variables involved. From experiment one, for example, it becomes clear that the initial inoculation rate has very little to do with the amount of time the disease remains active within the population. However, this is because larger initial inoculation rates limits *how many* individuals are affected at each time step, not *whether or not* they are affected. More specifically, a larger initial inoculation rate means a smaller subpopulation of infectable individuals but also a smaller rate of infection, balancing out the amount of time that the disease lasts (the inverse is applicable as well).

Experiment two was a set of three trials that each varied a different factor (trial one acted as a control, while trial two and three modified the number of interactions and the disease duration, respectively). As seen in Figure 02, increasing the number of interactions greatly sped up the course of the disease (which makes intuitive sense) while allowing the disease to remain in an infected person longer stretched the lifespan of the contagion by a nominal amount but also drastically increased the number of people that were infected at any given time step (which also makes intuitive sense).

Experiment three investigates the concept of "herd immunity." According to Figure 03, at levels of low immunity, there are very small numbers of uninfected members because there is a greater probability of interacting with an infected person. However, at one point (at around $immunity = 0.7$), there is an incredibly large number of uninfected people. This occurs because a significant amount of the population is inoculated, and therefore decreases the chances of a susceptible person coming into contact with an infected person. After this point, the number of inoculated people is so large, the number of susceptible people is decreasing and, therefore, decreases the amount of people who remain susceptible at the end.

Overall, the concept of "herd immunity" and disease propagation is an incredibly interesting natural phenomenon that is studied heavily with SIR models. This study examined a very limited number of possible relationships that may exist between the given variables, and further research would do well to dive a little deeper into the specific mechanics of the contagion and how they impact the population.