**Topics in Biostatistics**

Final Project: Infectious Disease Modeling – Looking at SIR Models

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This quarter we covered three main Biostatistics topics including clinical trials, survival analysis and infectious disease modeling. I found infectious disease modeling to be the most interesting topic we discussed, particularly because of its relevance in the COVID-19 pandemic. A YouTube video “Simulating an epidemic” by user 3Blue1Brown sparked my interest in creating an SIR model to simulate viral transmission.

SIR stands for “Susceptible, Infectious, and Recovered/Removed.” Susceptible refers to those in the population who are at risk of contracting the disease and infectious refers to those who are actively infected. Removed or recovered can be a little more complicated, as it refers to those who get the disease again while in this current state. This could be due to vaccination, natural immunity, (i.e. getting COVID-19 and your body creating antibodies) or due to death from the disease. Sometimes people in recovered/removed can return back to the susceptible category. For example, COVID-19 antibodies that are naturally acquired from infection are thought to last about 3 months, so 3 months after initial infection a person could theoretically lose immunity and return to the susceptible category. For simplicity, removed individuals were not put back into the susceptible category in our simulation.

To set up our simulation, we created a group of 100 “people” randomly scattered around a graph with bounds [0,1] for the x and y axis. This was considered to be a “city block” with about 100 people in it. Next, we had to randomly move the “people” to simulate walking, and we had to store each new timepoint without overriding the previous timepoint. We researched the probability of COVID-19 transmission and infection based on mask usage and came to the conclusion that a sick person wearing a mask reduces chance of transmission by 70% and an uninfected person wearing a mask reduces chance of infection by 80%. Lastly, we chose to modify certain parameters in our simulation to see how they would affect transmission. The parameters we chose in our simulation were mask usage, the distance the virus can travel, the number of days someone is infected for, the general infection probability, and how many people are starting with the disease (which would be a constant 15 people in our scenarios).

We started by creating the worst possible scenario which was found to be low mask usage (5%), 15 starting infections, 10 days of infection, an infection probability of 95% and could travel 0.1 units. I increased mask usage to 50%, but the proportion of population that became infected only decreased slightly. I also tried decreasing number of days infected to 3 but the majority of the population still became infected. This scenario showed us that a very contagious virus (i.e. a virus with a high infection probability) will still spread through the majority of the population even if there are limited mitigation practices in place.

When then tried to create the best possible scenario, implementing high mask usage at 95%, 15 starting infections, a 3-day infection and an infection probability of 10%. This scenario showed us that a less contagious virus can be contained really well with high mitigation practices in place, like mask usage and quarantining. The decreased number of days infected from 10 to 3 days can be thought of as quarantining. Without quarantining, an infectious individual is interacting with the public for 10 days but with quarantining an infectious individual is interacting with the public for only 3 of those 10 days that they remain infected.

These simulations can help us understand why COVID-19 was able to spread throughout a large portion of the U.S. population. COVID-19 is a contagious virus (moderately-high infection probability), and when not contained properly (i.e. high mask usage and quarantine) it will spread throughout most of the population. Other countries, like South Kora, who implemented strong quarantine and mask usage regulations were better able to control the spread than countries who did not implement strong mitigation tactics, like the U.S..