Modeling Diseases with the SIR Model

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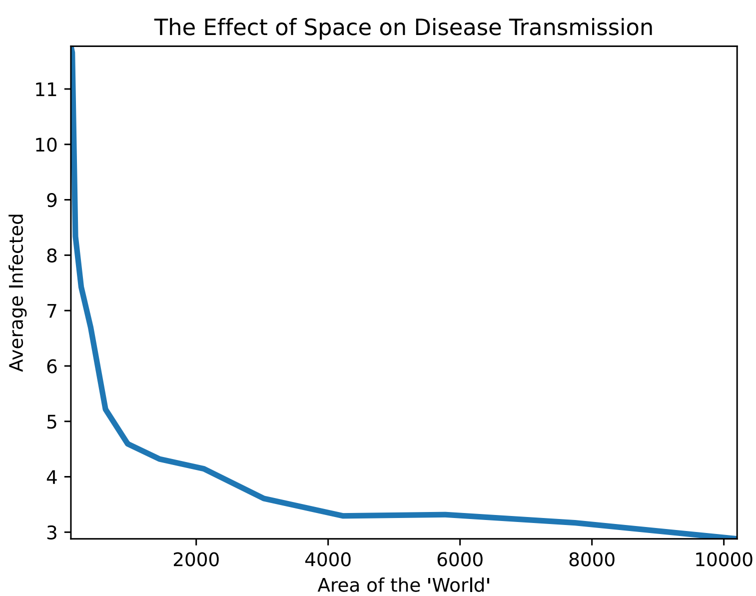
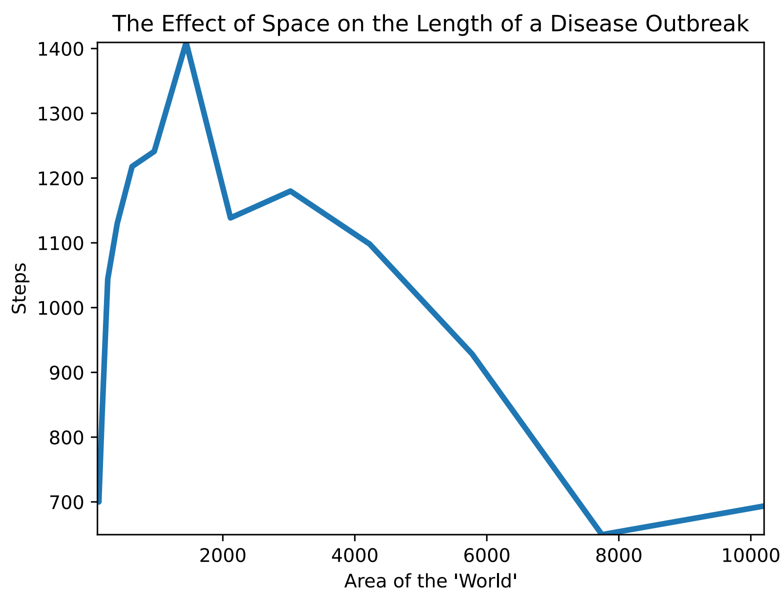
1 Increasing Area

When an outbreak occurs, the area people have to move around in should have an impact on how quickly the infection spreads, and how many people become infected. For this experiment, a few changes were made to the SIR*SIR Model* (2020) program: people can either cough or sneeze, and coughs or sneezes have different ranges in which they spread disease. Sneezes can generate up to 40,000 droplets, and coughs up to 3,000*Coughs and Sneezes: Their Role in Transmission of Respiratory Viral Infections* (2020). A sneeze can go up to 13 arbitrary units(au), and a cough can go 6 au. The data is ran 15 times per area measurement, and the average infected of that area is plotted. The length and width both increase by 1, starting at 10 and going to 15. The population included 100 people, with 1 being infected at first.



The way the SIR model simulates people walking, and the way the disease spread are modeled with random numbers. Still, the data should have some type of trend to it because the averages of each step were taken after several tests. As shown here, the number of average infected changes inversely with the area. The line goes down steeply, however, before flattening out. This could be because after a certain point, the area is too large to have any more significant effect on the spread of a disease.

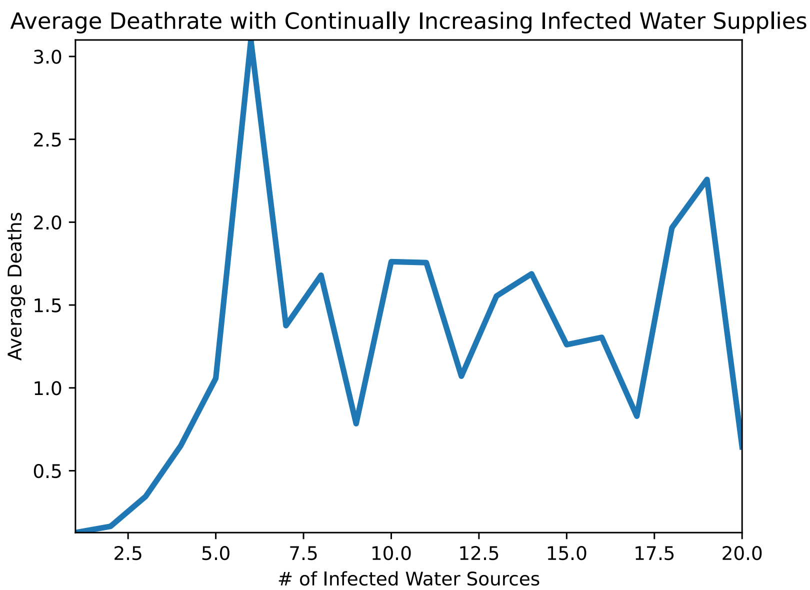
Increasing the area, however, may not exactly shorten the time of the infection. A large area means infected people are less likely to spread infection, but that doesn't mean the infected people will recover faster. The next experiment was modified so that instead of returning the susceptible, infected, and recovered number, it returned the number of 'steps' the disease went through. As before, the height and width were increased by 1, from 10 to 25, and the average number of steps were taken for each height.



The time of a disease outbreak with area accounted for spiked, before dropping, spiking up, and decrease in a smooth line. Increasing the area may not exactly shorten the time of the outbreak, as the time it takes for an infected person to recover is not impacted by an increasing area. Rather, it just makes it harder for infected people to spread infection. This could shorten infection time if the people recovered faster, but otherwise it could take longer for the disease to die out. There is a very noticeable low in the graph, and this could represent a preferable area.

2 Water Sources

For this model, a getWaterSources method was added that returned a number of water sources at random coordinates, within the size of the world. The number of water sources to generate was a constant, and so was the number of infected sources. The infected sources were generated when the rest of the sources were. For this experiment, the disease only spread via infected water source, and for 100 steps dead bodies are infected. It was only 100 steps because dead bodies are usually not very infectious. *Are there disease risks from dead bodies?* (n.d.) (Dead bodies are people who've gone into the lost category and stopped moving.) This time, the number of infected water sources was increased. The y-values were obtained from getting the average from 50 different runs of the same number of water sources.



While the death rate increased steeply, it did not stay constant. Instead, it dipped down unpredictably. This could be because the chance of someone dying is purely random, and instead the number of infected people could have increased greatly with the number of infected sources. Therefore a higher number of infected people did not seem to result in a higher death rate, because the chances of recovering or becoming 'lost' are completely random.

References

Are there disease risks from dead bodies? (n.d.). World Health Organization. Retrieved from https://www.who.int/water$_{s}anitation_{h}ealth/emergencies/qa/emergencies_{q}a8/en/$

Coughs and sneezes: Their role in transmission of respiratory viral infections. (2020, Sep). National Center for Biotechnology Information. Retrieved from https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7462404/

Sir model. (2020). Wikipedia Foundation. Retrieved from https://en.wikipedia.org/wiki/Compartmental$_{m}odels_{i}n_{e}pidemiologyThe_{S}IR_{m}odel$