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LCS2496

SDS 322

Disease Propagation Modelling in C++

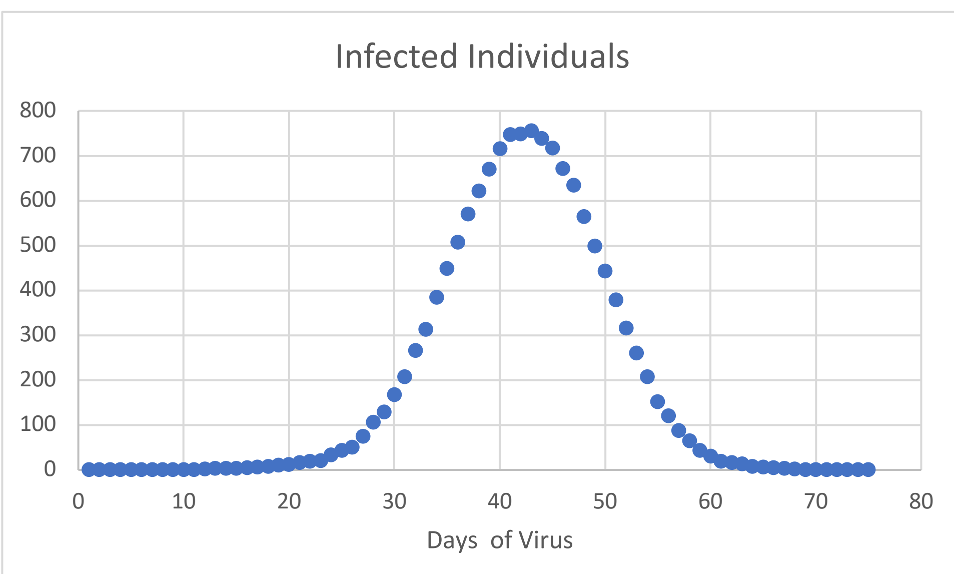
Parameters

In modelling this hypothetical disease, loosely based on COVID, a random patient zero in a population was infected, with each successive step having a chance of transmitting it to a susceptible individual. After a certain number of days, an individual would become immune to reinfection. As well, some individuals started off as vaccinated, so they could not contract the virus at all.

Generally for these experiments, I used a population size of 40000, approximately the population of undergraduates at UT-Austin, with an estimated transmission probability of 5% per interaction and 40 interactions per day. Infected people were set to be sick and infectious for 5 days before becoming cured and immune to reinfection. In this model, the disease is assumed to be 100% non-lethal.

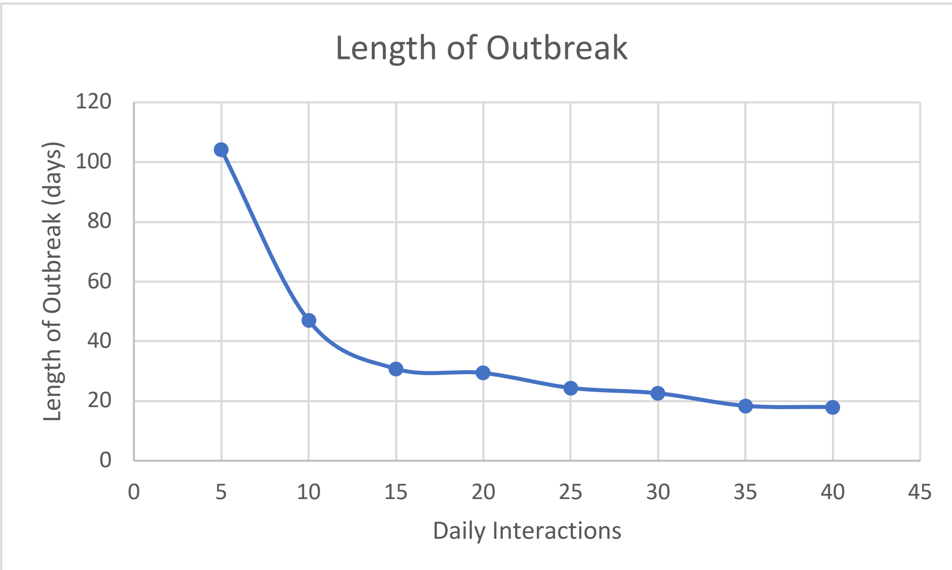
In the real world, there is no COVID vaccine, and rigorous social distancing measures have been put in place to reduce the number of potential disease transmissions.

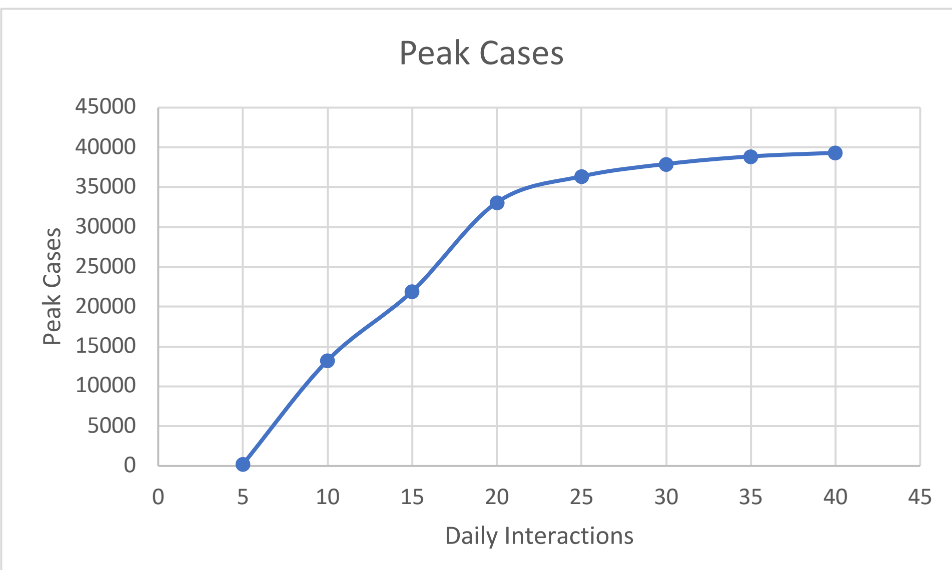
Experiment 1: Is the curve normally distributed?



The disease propagation model is working correctly when there is a Gaussian peak in cases. This test with a population of 1000 demonstrates that with no prevention measures, the virus will peak and die off along the normal distribution.

Experiment 2: Does social distancing help?

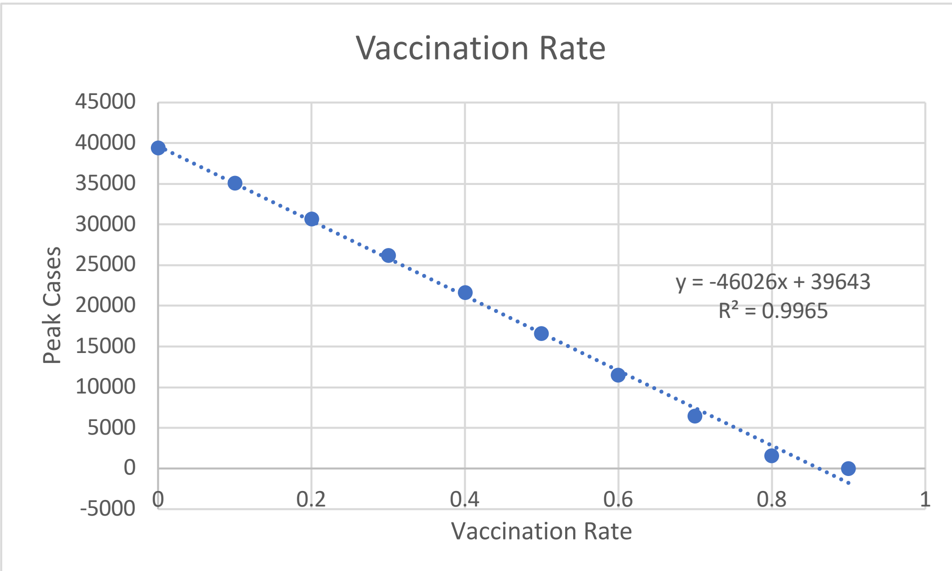




As the number of interactions each person has each day increases, the total length of the outbreak decreases. This might seem good, but it's important to remember that this decrease comes as a result of many more people becoming infected. For these tests, the average of 5 trials was taken due to the randomness involved in generating the simulations. Based on this graph, keeping daily interactions below 20 reduces the total cases significantly.

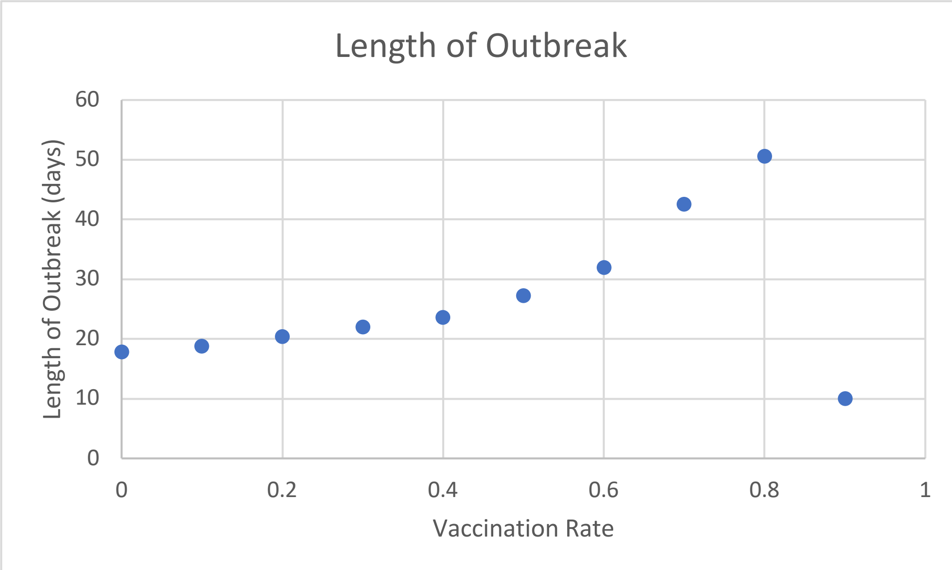
Experiment 3: The Vaccination Rate

Ideally, 100% of the population would be vaccinated. However, in the real world this isn't possible. There are a substantial number of people who for one reason or another cannot receive vaccines, such as newborns and the immunocompromised, as well as those who object to vaccines or do not have access to medical care.



For this experiment, the average of 5 trials was used to determine the peak cases. The number of peak cases linearly decreased with an increase in the vaccination rate. This confirms the obvious, that the more people are vaccinated, the better.

"Herd immunity" protects those who cannot get vaccinated by stopping the disease before it is able to spread. That way, susceptible people never come into contact with the virus, because everyone who can get vaccinated becomes unable to transmit the disease. Based on the above graph, 95% of the population will not get infected with the disease with a vaccination rate of about 80%, given the specified parameters. However, a more infectious disease could easily change this required vaccination rate.



As the vaccination rate improves, the length of the outbreak increases, until eventually an outbreak becomes so minor due to the small vulnerable population.

Data

The program used to generate this data, as well as an Excel notebook with the data and plots, plus a sample output file used to generate the data, can be found in the enclosed directory.

Conclusions

This model is unsophisticated, but still provides valuable insight into the ability of diseases to spread unchecked given what seems like a small transfer probability and a reasonable number of person-to-person interactions. COVID-19 is scarier than this model given its longer duration (often said to be around 14 days rather than 5 as in this model), with asymptomatic transmission and a significant mortality rate. A more sophisticated model would take these parameters into account, perhaps by randomly generating the age of individuals in the population and applying probabilistic methods to determine their chance of survival given prior knowledge.