

Controlling Disease Through Testing

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Modeling Question

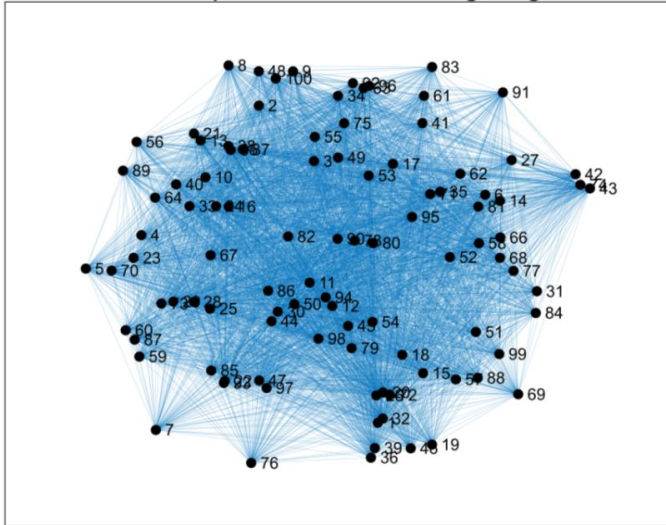
How often do we need to test in order to have the peak number of infected people lower than 20?

This is a design question as it aims to discover exactly how often tests must be administered in order to achieve a certain peak number of infected persons.

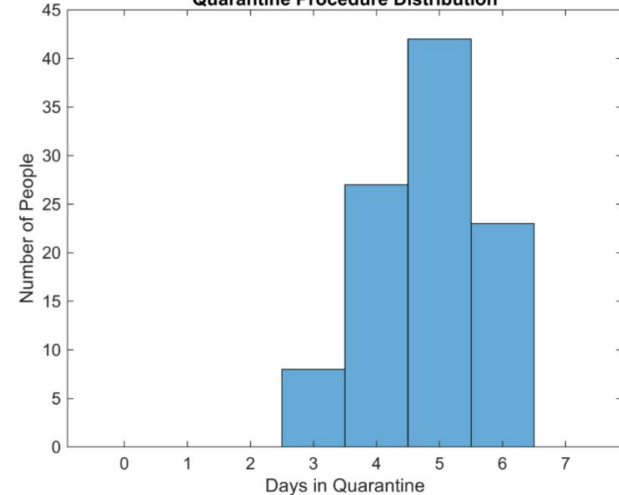
Model Setup

- Creates a 100 person adjacency matrix with randomized edge weights from 0 to 3
- Creates a beta distribution for the quarantine length

Social Graph with Randomized Edgeweights



Quarantine Procedure Distribution



Model Simulation

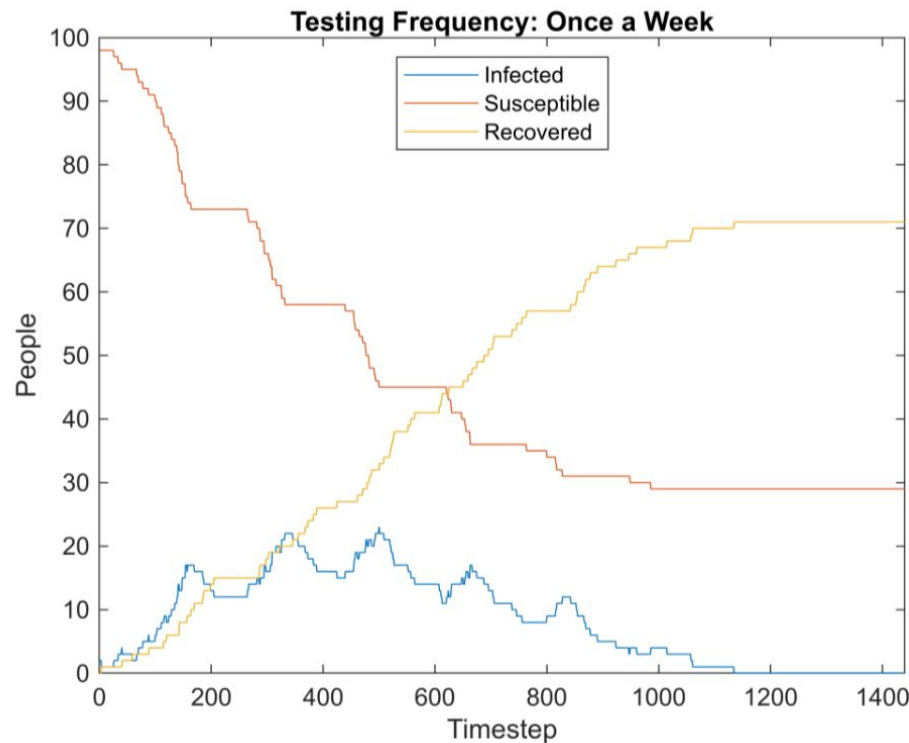
- Uses a modified agent based simulation function with added parameters of testing frequency and the beta distribution
- Keeps track of Susceptible, Infected Quarantined, Infected Unquarantined, and Recovered
- Each timestep is one hour
- We will test frequencies between once every hour and once every 550 hours (approximately 22 days)

Assumptions

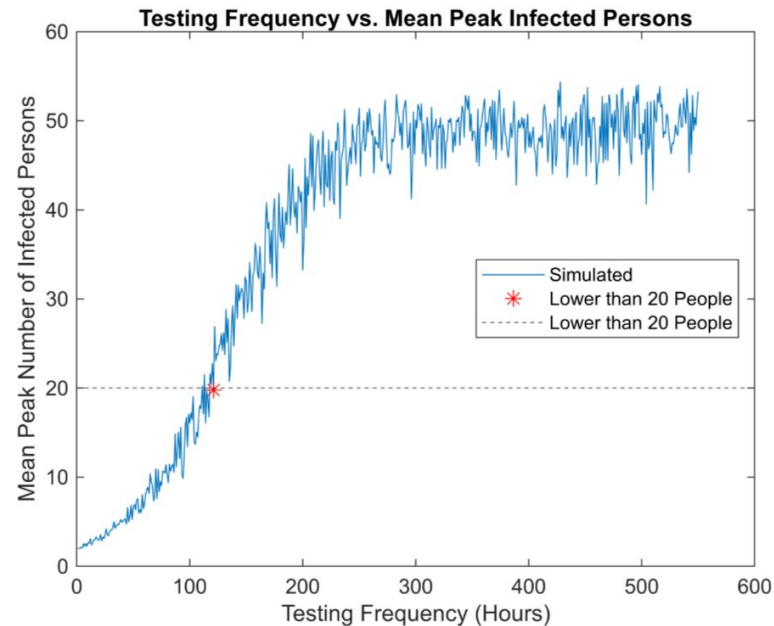
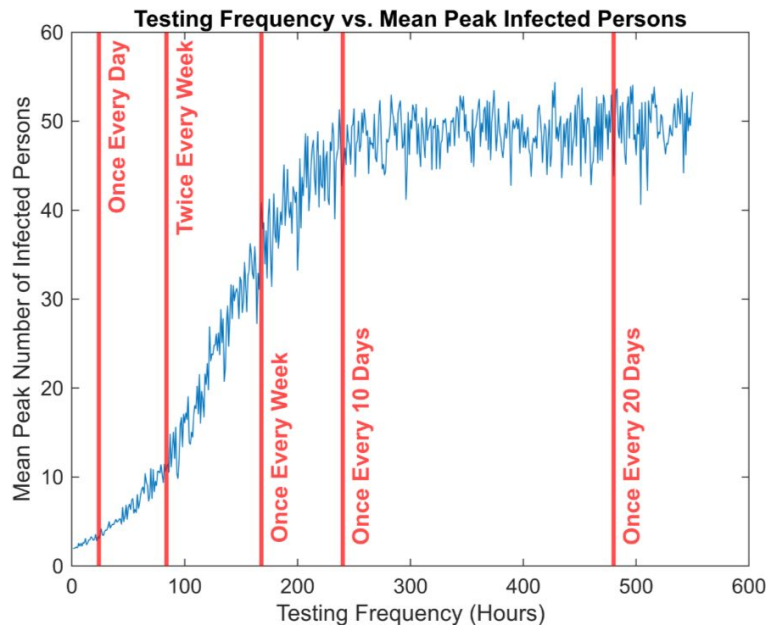
- Every person who receives a positive test will immediately go into quarantine with no delay
- A quarantined person will have zero interaction with anyone else during their isolation period
- The maximum edge weight values in the population matrix are completely arbitrary
- The Covid tests are always accurate
- Persons who were previously infected cannot be reinfected
- The infection rate is constant for every person
- No person in the model is vaccinated
- Every person has an identical immune system (recovery rate)

Results

- Fluctuating infection peaks due to repeated mass quarantining
- Infection picks back up when people leave quarantine



Parameter Sweeps



Need to test once every 121 hours to bring peak below 20 people!

Interpretation

The effect of the testing can clearly be seen in the first simulation output graph, where testing was conducted once a week. After an initial infection peak, the infected line sharply decreases as people quarantine themselves. This is followed by slight residual infection peaks as groups of people come out of isolation. The frequency of testing has a large effect on the mean infection peak as shown in our parameter sweep. However, testing less frequently leads to a much more widespread infection, until you exceed 10 days without them and the sweep begins to level off. Obviously, if you wish to reduce the spread of the disease as much as possible, you would also be testing as frequently as possible. It is not reasonable however, to expect people to test themselves multiple times a day or even every day. Ideally, everyone would test themselves twice a week, as this brings us below our 20 person threshold.

Verification and Validation

The peer-reviewed research paper "Frequency of Routine Testing for Coronavirus Disease 2019 (COVID-19) in High-risk Healthcare Environments to Reduce Outbreaks", published in Oxford's scientific journal Clinical Infectious Diseases closely mimics the results found with our model. In their model, they create a model of (basic reproduction number or the number of secondary infections) in a relationship with testing frequency. In examining this model and their results, they concluded "that routine testing substantially reduces risk of outbreaks, but may need to be as frequent as twice weekly". Similarly, we found that testing on a regular basis significantly lowers the spread of disease... but only if tests are administered more than once a week. If tests are administered at a rate of once a week or less frequently, there is little to change in the spread of disease. Additionally, in order to highly contain the disease, testing should be administered at least twice a week, as this reduces the peak by 75%. Because our model produces very similar results to a model in a peer reviewed, highly renowned scientific journal, we can safely assume our model's result are highly accurate.

Source: <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7797732/>