# Simulating covid spread at William Jewell and the effects of testing and intervention

Connor Morehouse

January 2021

# Outline

- Goal
- The Network
- The Simulation
- The method of intervention
- The Results
- Discussion

# Definitions

- Nodes represent students and are represented by $n$

# Definitions

- Nodes represent students and are represented by $n$
- Edges represent links between students and are represented by $m$

# Definitions

- Nodes represent students and are represented by $n$
- Edges represent links between students and are represented by $m$
- Scaled network density is a ratio of edges to nodes represented by $d = \sqrt{m}/n$

# Definitions

- Nodes represent students and are represented by $n$
- Edges represent links between students and are represented by $m$
- Scaled network density is a ratio of edges to nodes represented by $d = \sqrt{m}/n$
- We use scaled network density because it allows us to compare networks with different size $n$.

# Goal

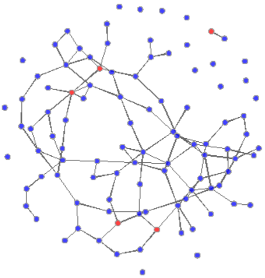
- Simulate the spread of Covid-19 at William Jewell and the effects of testing and quarantines

# Goal

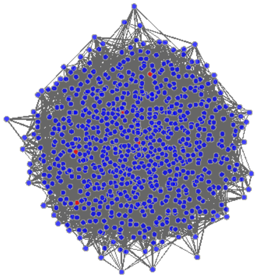
- Simulate the spread of Covid-19 at William Jewell and the effects of testing and quarantines
- We were interested in finding a reasonable testing rate that would prevent the peak of infections greater than 150.

# The Network

- The network is an Exponential Random Graph network



(a) nodes = 100

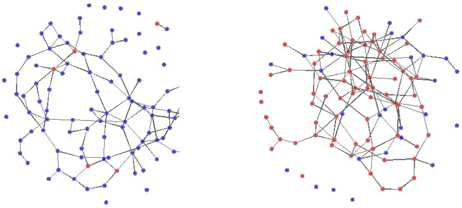


(b) nodes = 750

Figure: Blue is susceptible, Red is infected, Green is recovered

# The Network

- The network is an Exponential Random Graph network
- The network is a Stochastic network, meaning it changes over time.

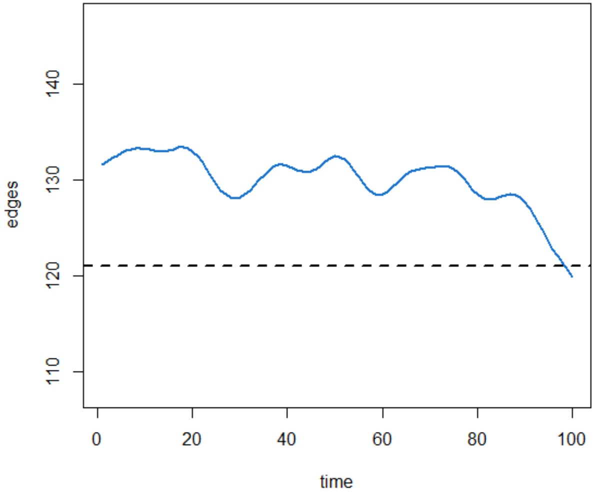


(a) time step = 1 (b) time step = 30

Figure: Blue is susceptible, Red is infected, Green is recovered

# The Network

Edges vs Time



# The Network

- The network is an Exponential Random Graph network
- The network is a Stochastic network, meaning it changes over time.
- We used parameters of similar observed networks to set target statics of our network.

# The Network

- The network is an Exponential Random Graph network
- The network is a Stochastic network, meaning it changes over time.
- We used parameters of similar observed networks to set target statics of our network.
  - Most notably scaled network density, $d$.

# The Network

- The network is an Exponential Random Graph network
- The network is a Stochastic network, meaning it changes over time.
- We used parameters of similar observed networks to set target statics of our network.
  - Most notably scaled network density, $d$.
  - We chose real world networks that had similar structures to class schedules, one student works in close contact to a few small groups of other students.

# The Network

- The network is an Exponential Random Graph network
- The network is a Stochastic network, meaning it changes over time.
- We used parameters of similar observed networks to set target statics of our network.
    - Most notably scaled network density, $d$.
    - We chose real world networks that had similar structures to class schedules, one student works in close contact to a few small groups of other students.
        - passengers in an airport $d = .11$
        - network of co-workers $d = .13$

# The Model

- We used an SIR model

# The Model

- We used an SIR model
  - S stands for susceptible.
  - I stands for infected.
  - R stands for recovered.

# The Model

- We used an SIR model
  - S stands for susceptible.
  - I stands for infected.
  - R stands for recovered.
- No recovered to susceptible flow due to length to natural immunity from infection.

# The Model

- We used an SIR model
  - S stands for susceptible.
  - I stands for infected.
  - R stands for recovered.
- No recovered to susceptible flow due to length to natural immunity from infection.
- Initial conditions are from the Operation safe campus end of fall semester report.

# Intervention

1. We first tested a proportion of the population.
2. If the student tests positive they are sent to quarantine and the probability of transmission was set to zero.
3. Once the student recovered, they were let out of quarantine.

# Assumptions

- Initial conditions of simulation based on Operations Safe Campus end of semester report from the fall semester.

# Assumptions

- Initial conditions of simulation based on Operations Safe Campus end of semester report from the fall semester.
- No population flow from recovered to susceptible, the CDC states immunity can last up to 8 months.

# Assumptions

- Initial conditions of simulation based on Operations Safe Campus end of semester report from the fall semester.
- No population flow from recovered to susceptible, the CDC states immunity can last up to 8 months.
- The Network model assumes all students in a class to be close contacts, which my not be the case due to measures put forth in the classroom.

# Assumptions

- Initial conditions of simulation based on Operations Safe Campus end of semester report from the fall semester.
- No population flow from recovered to susceptible, the CDC states immunity can last up to 8 months.
- The Network model assumes all students in a class to be close contacts, which my not be the case due to measures put forth in the classroom.
- Testing occurs once a week and does not include contact tracing.

# Assumptions

- Initial conditions of simulation based on Operations Safe Campus end of semester report from the fall semester.
- No population flow from recovered to susceptible, the CDC states immunity can last up to 8 months.
- The Network model assumes all students in a class to be close contacts, which my not be the case due to measures put forth in the classroom.
- Testing occurs once a week and does not include contact tracing.
- each testing rate was simulated 30 times on newly generated networks, the values returned are the mean of the 30 simulations.

# Assumptions

- Initial conditions of simulation based on Operations Safe Campus end of semester report from the fall semester.
- No population flow from recovered to susceptible, the CDC states immunity can last up to 8 months.
- The Network model assumes all students in a class to be close contacts, which my not be the case due to measures put forth in the classroom.
- Testing occurs once a week and does not include contact tracing.
- each testing rate was simulated 30 times on newly generated networks, the values returned are the mean of the 30 simulations.
- No accounting for vaccinations.

# Results

First we check that the networks are forming as we expect, for $d = .11$ and $n = 750$ we expect $m \approx 6800$.

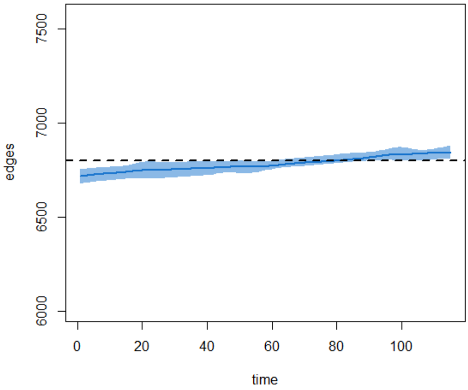



Figure: Total number of edges versus time

# Results

We'll take a look at the lowest and highest testing rate graphs

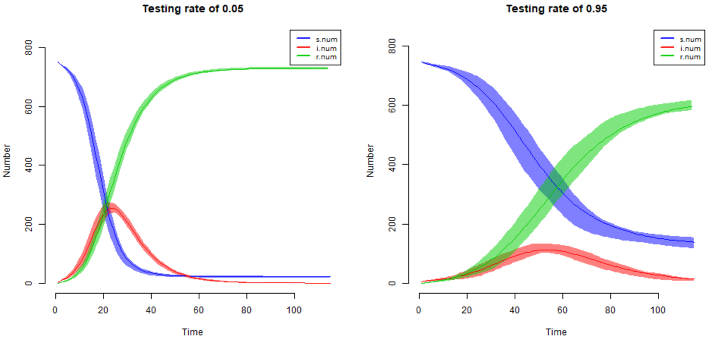
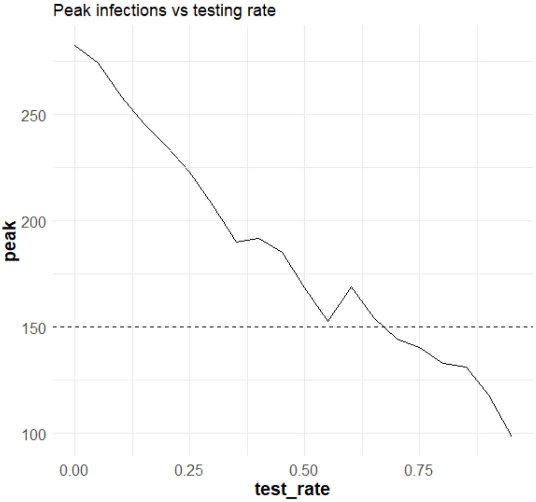



Figure: Blue is susceptible, Red is infected, Green is recovered

We can see a distinct difference in the height of peak infections and at what time it occurs.

# Summary of results




We can see that, for the target of 150, a testing rate of 50 percent might be viable, but a testing rate closer to 70 percent would be much more reliable.

# Future work possibilities

- Create an intervention method that includes contact tracing.

# Future work possibilities

- Create an intervention method that includes contact tracing.
- Account for vaccinations.

# Future work possibilities

- Create an intervention method that includes contact tracing.
- Account for vaccinations.
- If we knew the rate at which students in the same classroom were close contacts we could update the model to be more representative.

# Future work possibilities

- Create an intervention method that includes contact tracing.
- Account for vaccinations.
- If we knew the rate at which students in the same classroom were close contacts we could update the model to be more representative.
- With more information would could also test the necessary level of Covid polices in common areas.

# References


- Guy Melançon. Just how dense are dense graphs in the real world? A methodological note. BELIV 2006: BEyond time and errors: novel evaLuation methods for Information Visualization (AVI Workshop), May 2006, Venice, Italy, pp.75-81. fflirmm-00091354f
- Test and Treat Intervention for an SIS Epidemic EpiModel Gallery, Samuel M. Jenness (Emory University). August 2018 (https://github.com/statnet/EpiModel-Gallery)
- Jenness SM, Goodreau SM and Morris M. EpiModel: An R Package for Mathematical Modeling of Infectious Disease over Networks. Journal of Statistical Software. 2018; 84(8): 1-47.
- Lelieveld J, Helleis F, Borrmann S, Cheng Y, Drewnick F, Haug G, Klimach T, Sciare J, Su H, Pöschl U. Model Calculations of Aerosol Transmission and Infection Risk of COVID-19 in Indoor Environments. International Journal of Environmental Research and Public Health. 2020; 17(21):8114. https://doi.org/10.3390/ijerph17218114