

Spread Across Networks

ModSim 23-24 Project 2

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RESEARCH QUESTION:
**How does class size
influence disease spread
within a student population?**

RESEARCH

Background Information + References

- Post-COVID-19, schools have aimed to comprehend **disease transmission within classrooms** (*Hekmati*).
- **Limited research** is done on infectious disease behavior and effective prevention strategies (*COVID-19 Working Group*).
- Existing information is often based on **assumptions**, potentially leading to biased results (*COVID-19 Working Group*).

OBJECTIVE:
Understand the
impact of class sizes
on disease spread
and implement
effective preventive
measures to control
outbreaks in school
environments.



METHODOLOGY

Modeling Classes and Population

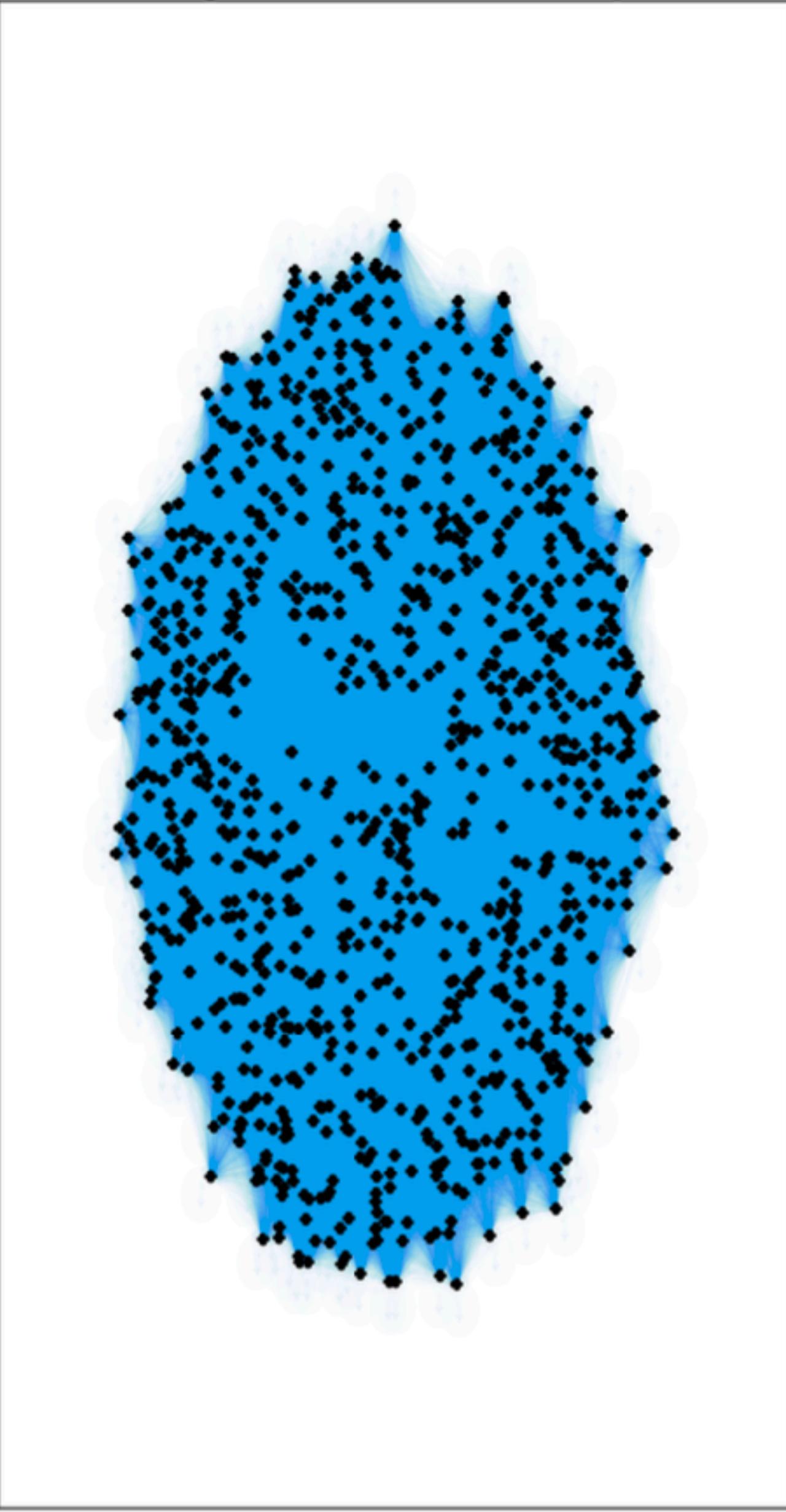
- Utilized the SIR agent-based model from worksheet four.
- Adopted a "**leaky pod**" agent-based model to represent classes as pods.
- The strength of connections within pods based on class size, represented as class size/total population ratio.
- Designed as a **complete graph** with relatively weak interconnections.

METHODOLOGY

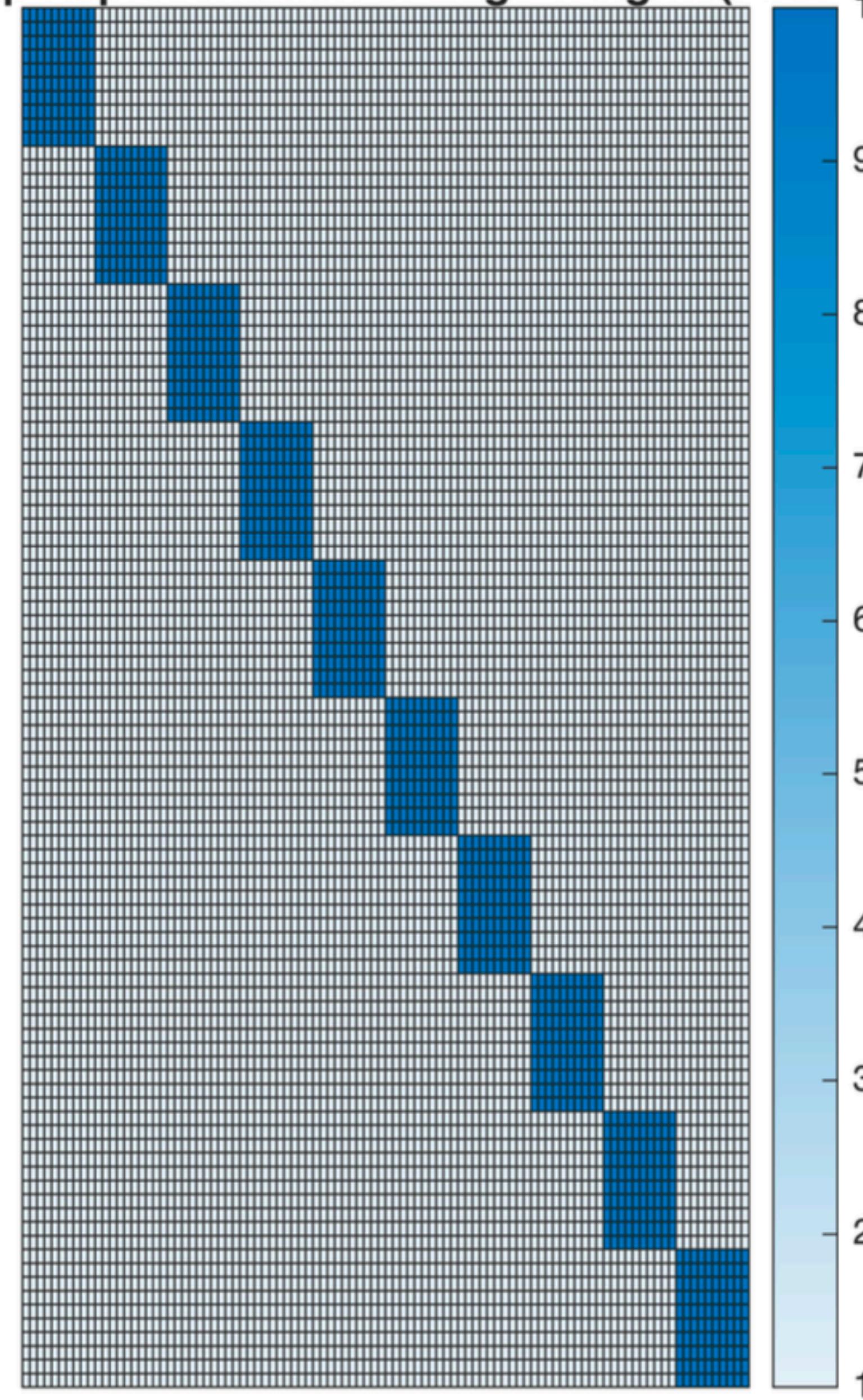
Assumptions

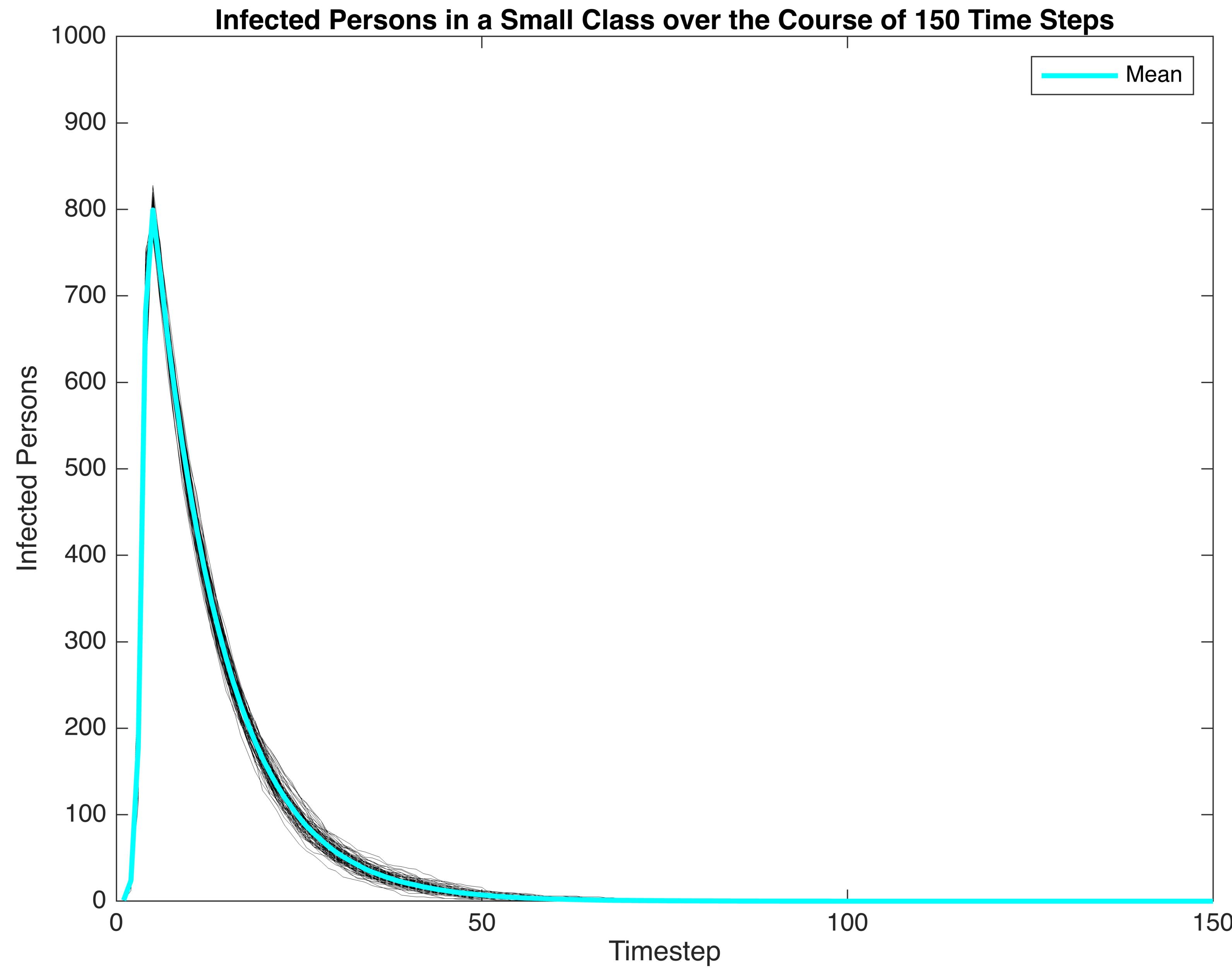
- Smaller class sizes promote stronger connections due to **interactive teaching styles**.
- **Complete interconnectedness** —> might not hold in larger colleges.
- **Equal connectivity** is assumed within each class.
- **Class sizes are assumed to be the same** for all classes —> real-life class sizes vary by student year.
- Small class = 10, Medium class = 50, Large class = 100.
- Total population = 1000.

Large Connected Graph



Heatmap Representation of Edge Weights(First 100)

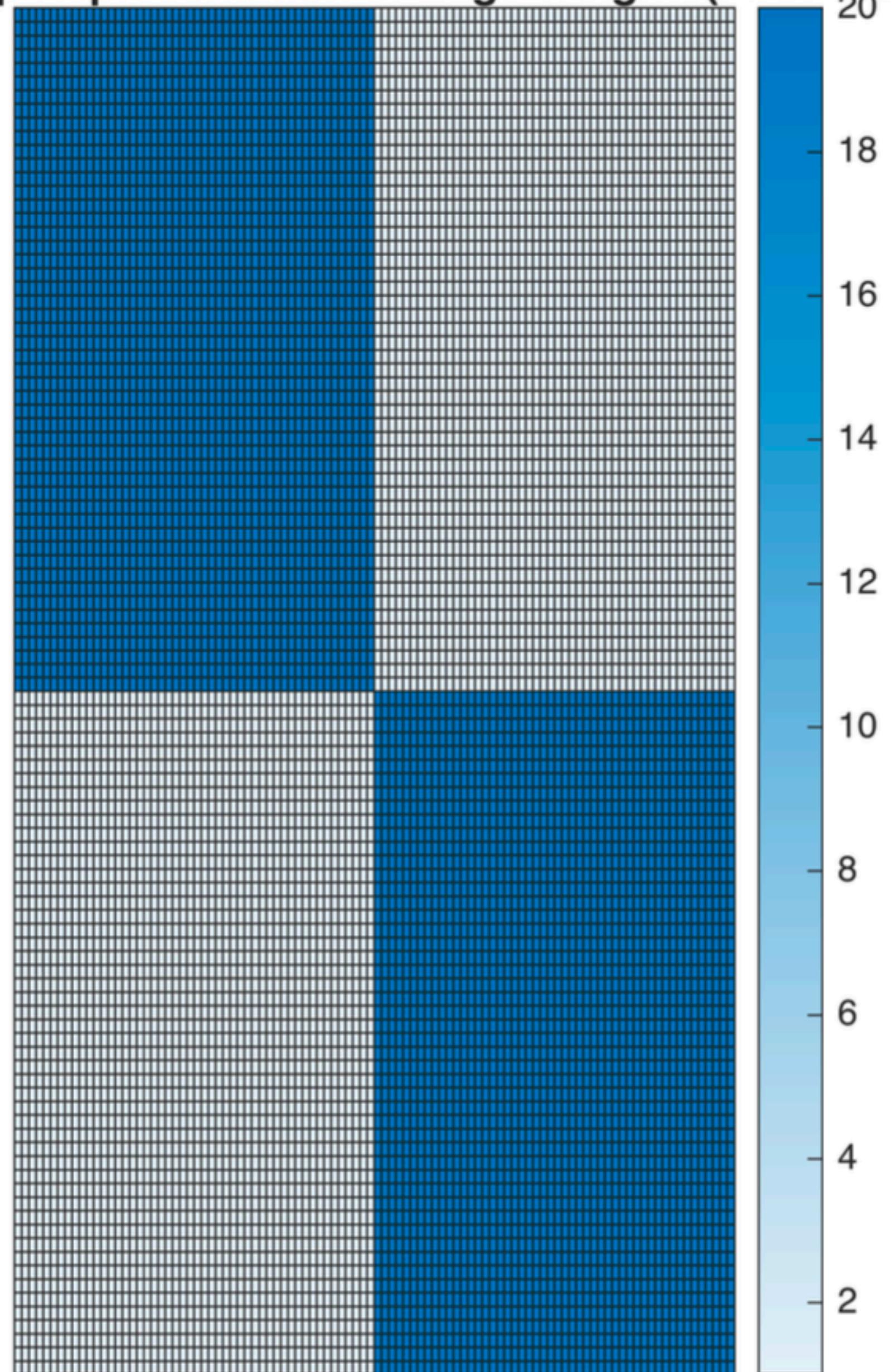


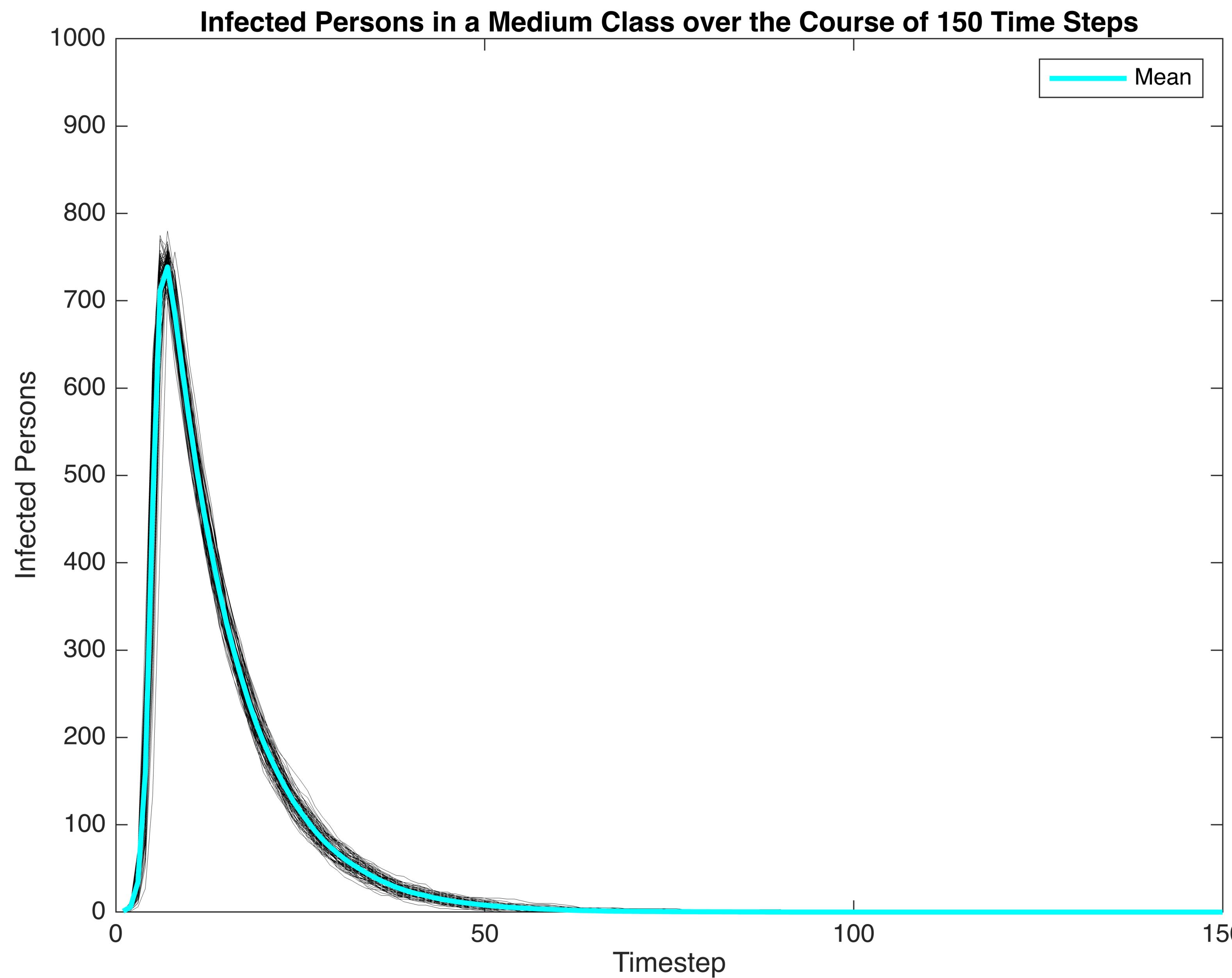


Medium Connected Graph

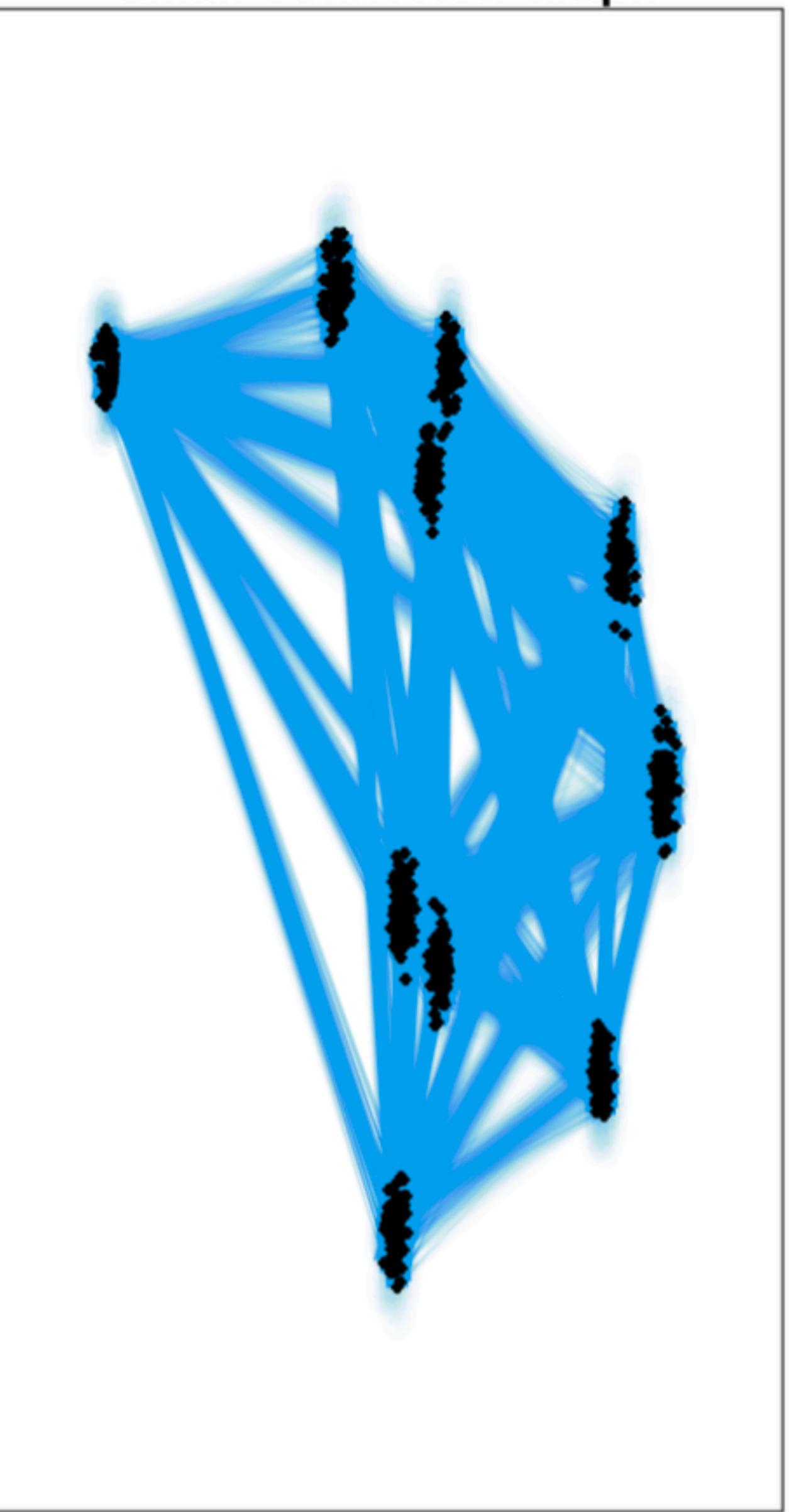


Heatmap Representation of Edge Weights(First 100)

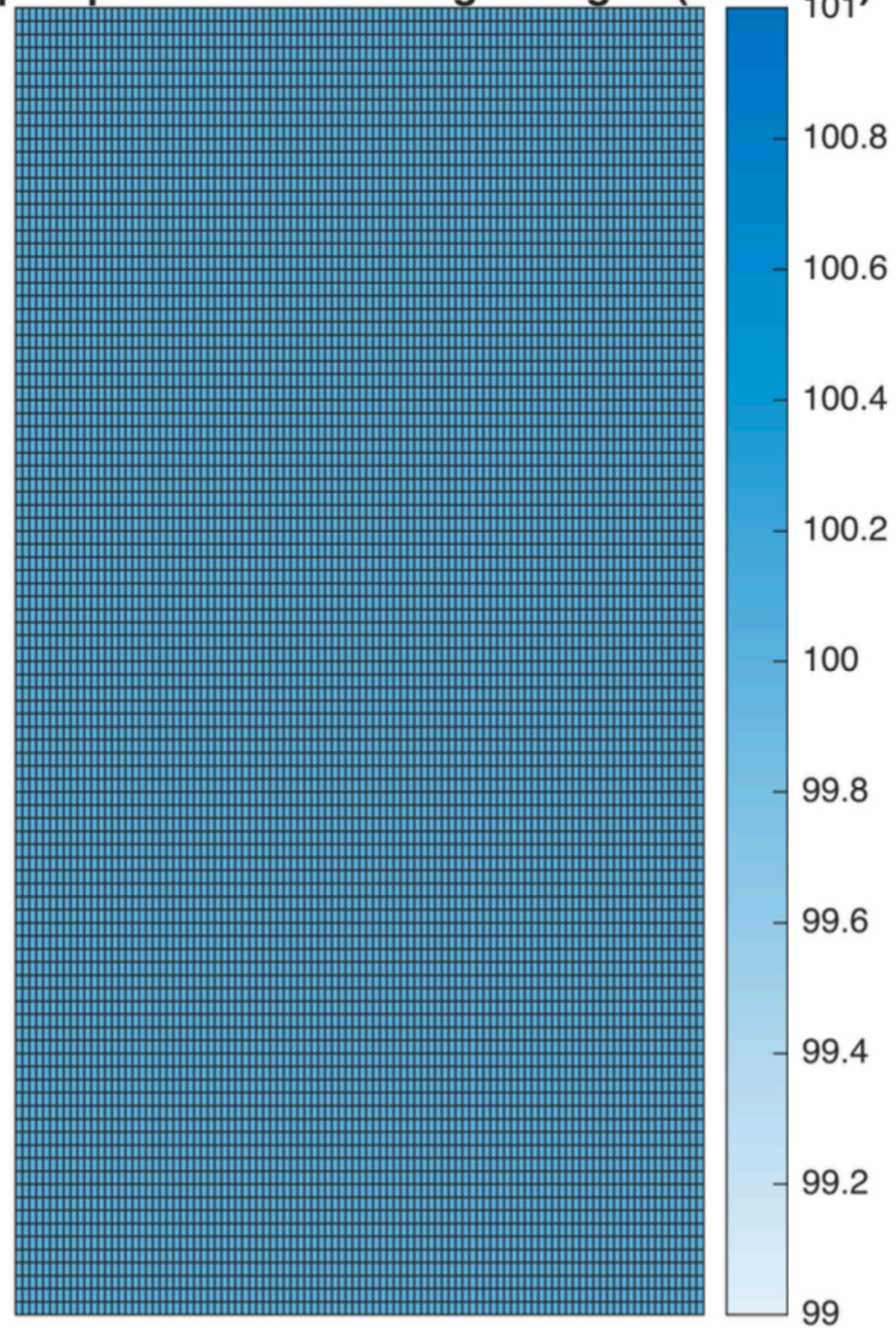


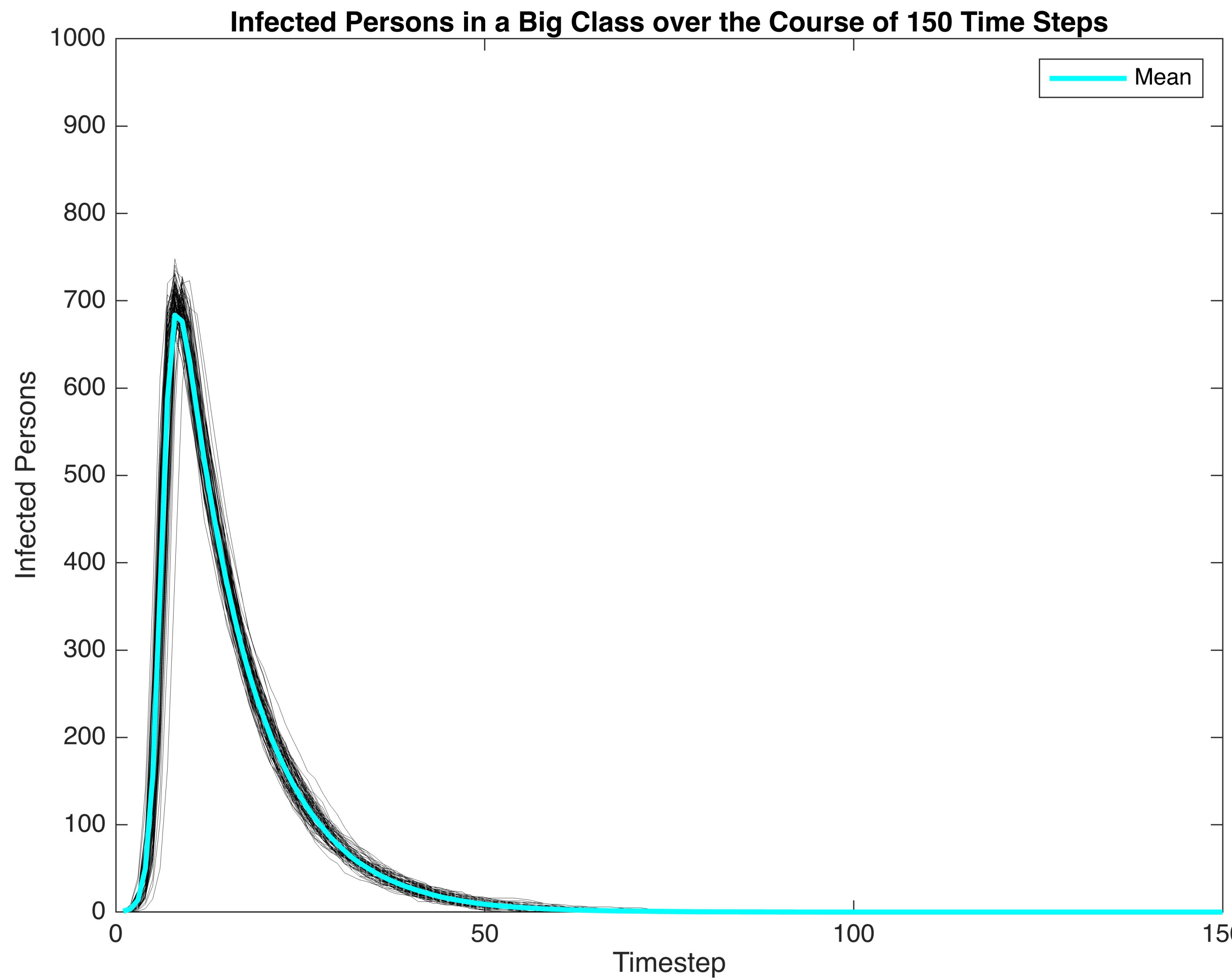


Small Connected Graph



Heatmap Representation of Edge Weights(First 100)





DEVELOPMENT

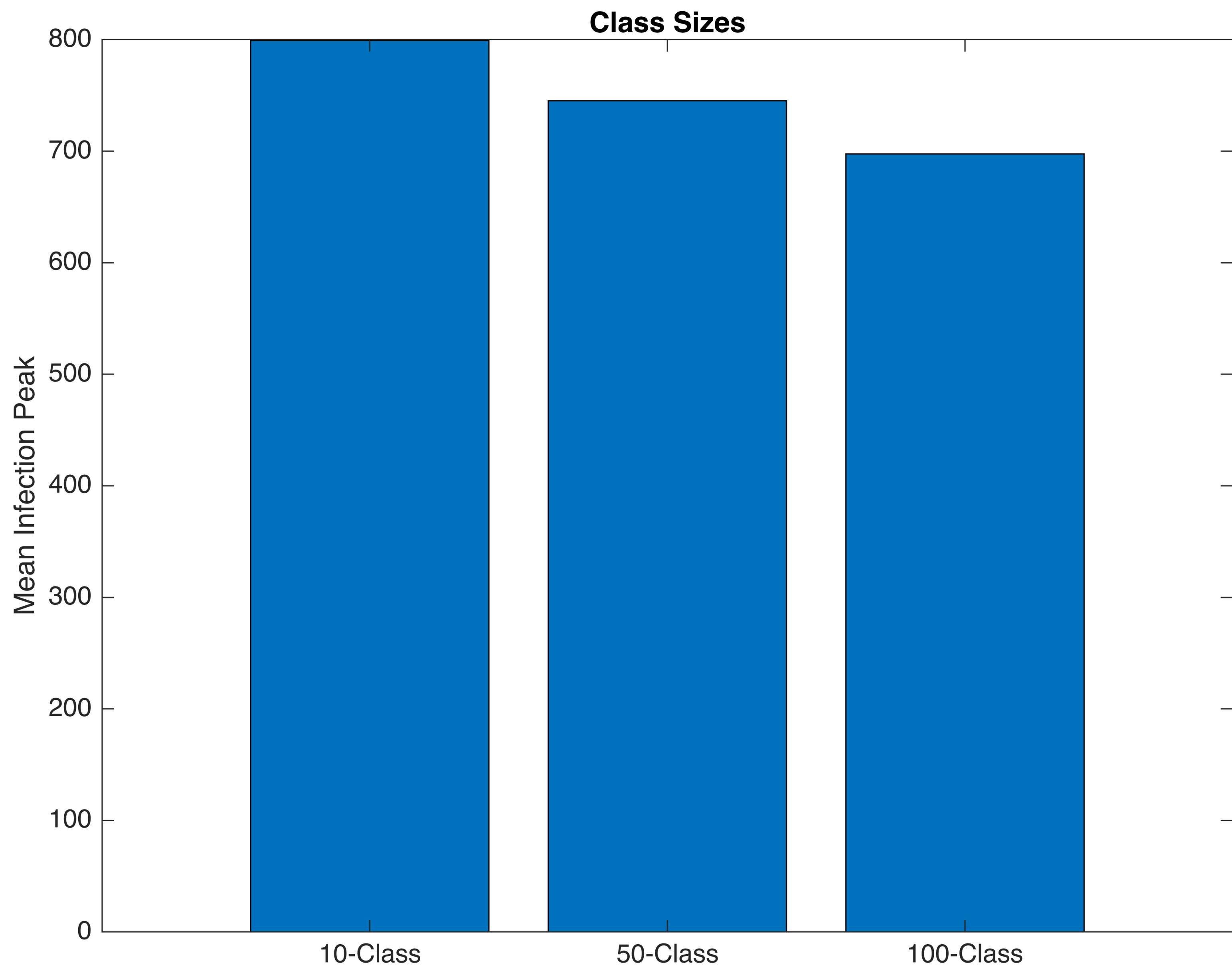
Verification Facts

- Checked for agents being in more than one state (value greater than one).
- Ensured agents weren't in multiple fractional states.
- Example:

```
%make sure agent is only in one state at a time
assert(sum(all(Ss+Is+Rs==1))==150)
%make sure an agent isn't in a fracional state(checking if rounding down
%in the matrix creates a matrix than is different from the original
assert(sum(all(floor(Ss) ~= Ss,'all')) == 0)
assert(sum(all(floor(Rs) ~= Rs,'all')) == 0)
assert(sum(all(floor(Is) ~= Is,'all')) == 0)
```

Parameter Sweeps

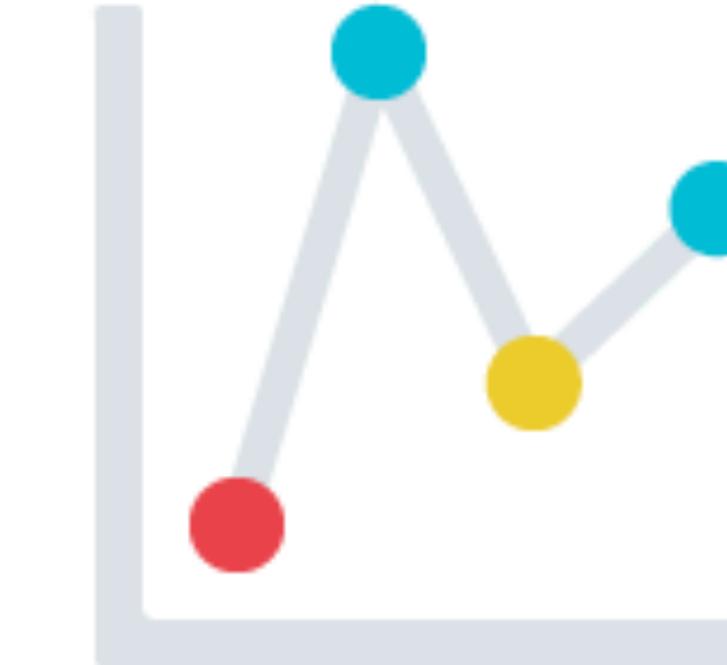




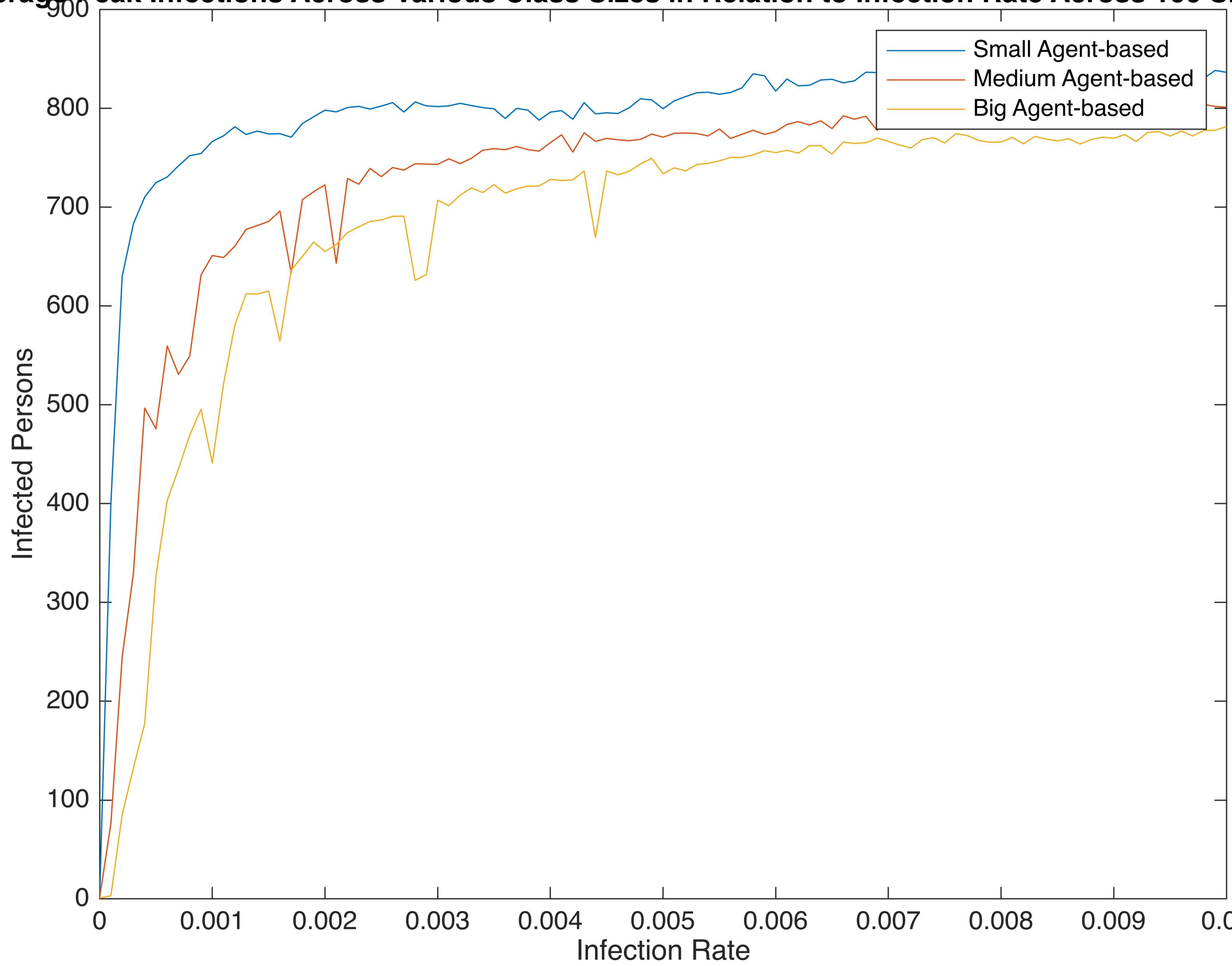
PARAMETER SWEEPS

Parameter Sweeps and Analysis

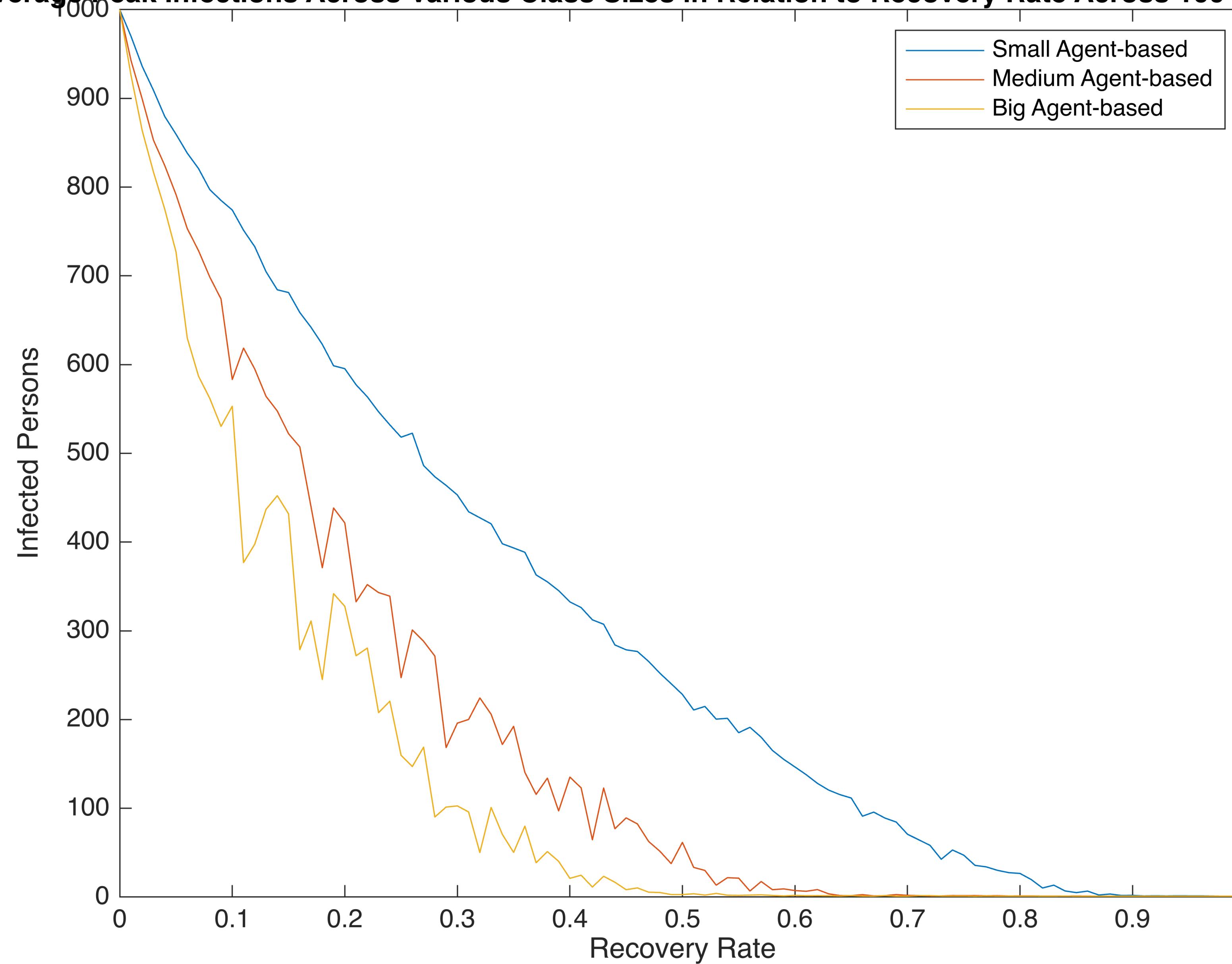
- Conducted parameter sweeps for **infection and recovery rates** across three class sizes (slides 17, 18).
- We used the metric of **mean peak infection** and calculated means based on 10 realizations due to computational limitations in MATLAB.



Average Peak Infections Across Various Class Sizes in Relation to Infection Rate Across 100 Simulations



Average Peak Infections Across Various Class Sizes in Relation to Recovery Rate Across 100 Simulations



ANALYSIS

Interpretations Based on Parameter Sweeps

- **Smaller classes exhibited the highest peak infections**, followed by medium and large classes.
- Trends held for realistic infection and recovery rates, avoiding exceptionally rapid trends.



ANALYSIS

Validation and Supporting Evidence:

- A study on seasonal influenza among primary school students (Matsumoto, Japan) mirrored **similar trends** with class sizes.
- Results for small and medium classes **align with the error margin** of this study (*Matsumoto, Japan*).
- Another study simulating COVID-19 in a university environment indicated that **moving large classes online effectively reduced COVID-19 infections**, aligning with our simulation data (*Simulating COVID-19 In a University Environment*).

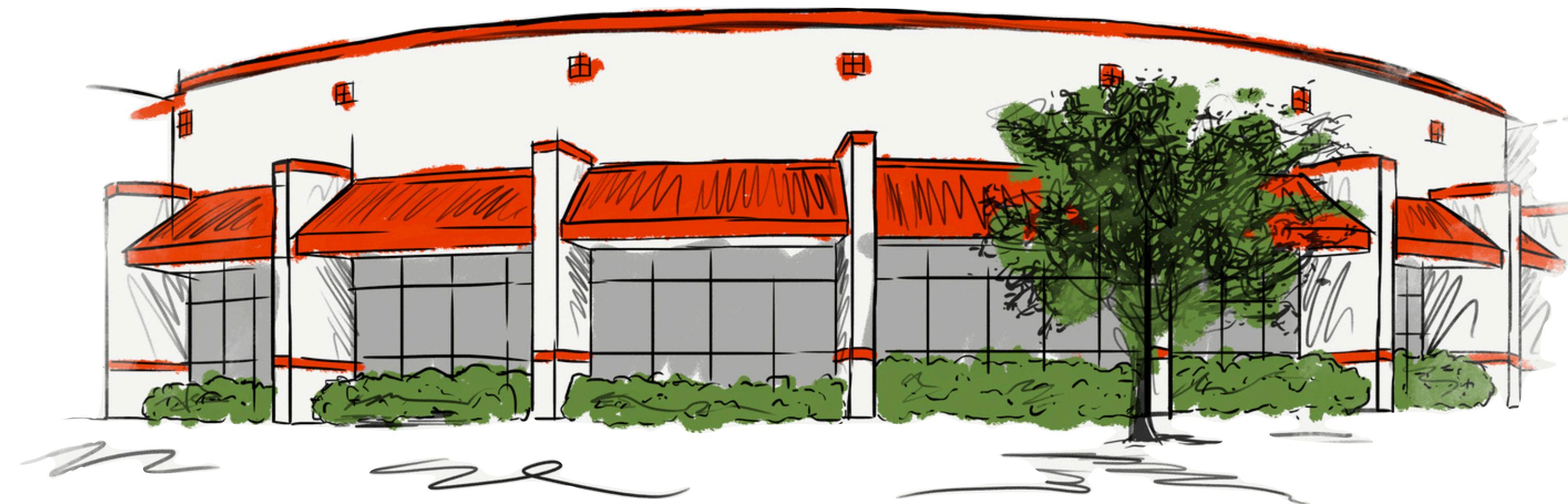
CONCLUSION:

**Smaller class sizes tend to result in
the most disease spread as compared
to medium or large classes.**

INTERPRETATION

Limitations

- School **complexities** (varying class sizes, social circles, teachers, dormitories) were not incorporated, impacting model accuracy.
- Model designed for smaller to medium-sized schools; **assumptions may not hold for larger institutions.**



INTERPRETATION

Future Work

- Include **additional school intricacies** to represent larger educational settings better.
- **Increase realizations** for parameter sweeps to gather more robust data for meaningful conclusions.

