

# **Spread Across Networks**

## **ModSim 23-24 Project 2**

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**Date:** Nov 8 2023



**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

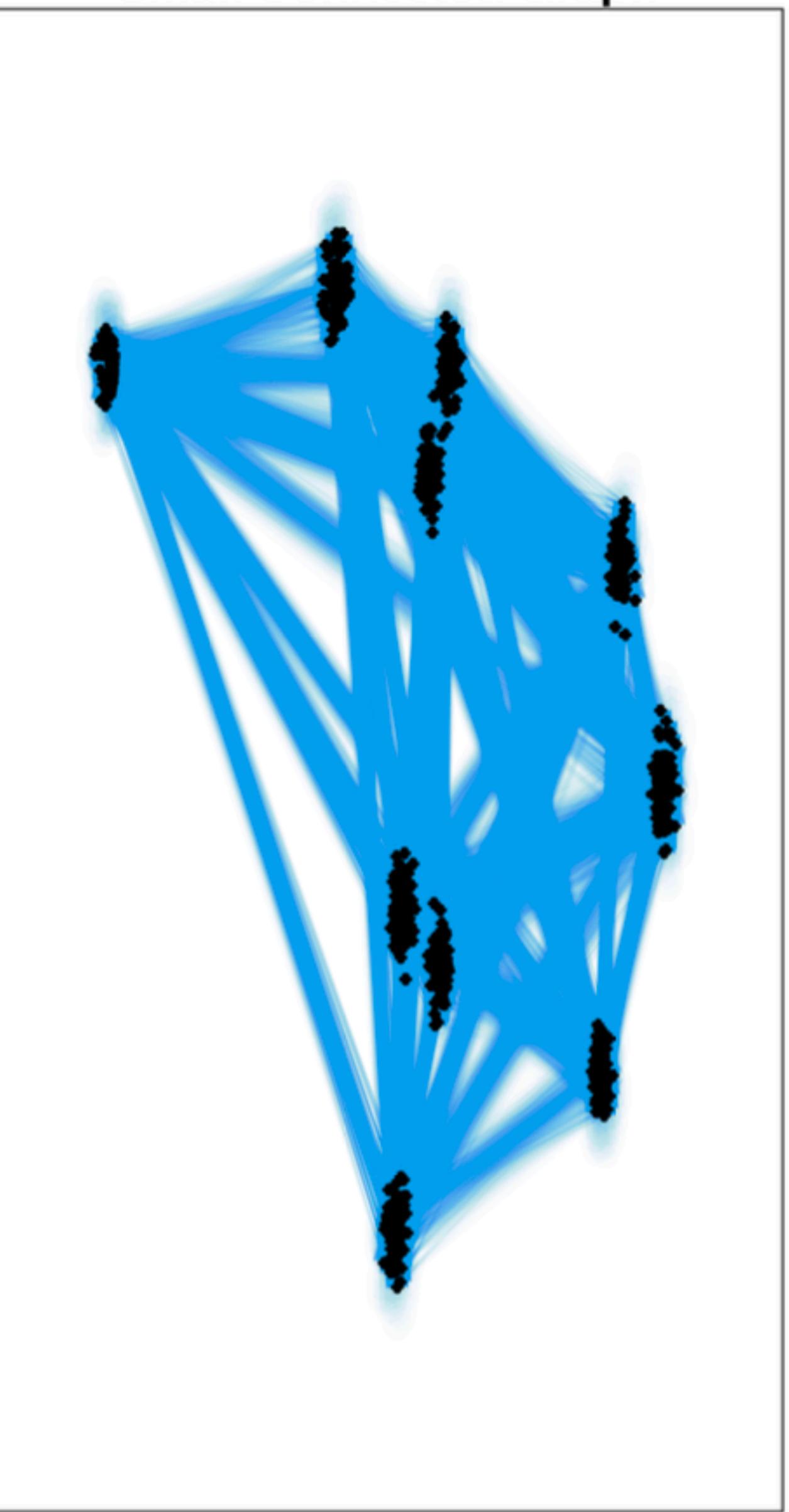
- Utilized the SIR agent-based model from worksheet four.
- Adopted a "**leaky pod**" agent-based model to represent classes as pods.
- The strength of connections within pods based on class size, represented as class size/total population ratio.
- Designed as a **complete graph** with relatively weak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

# METHODOLOGY

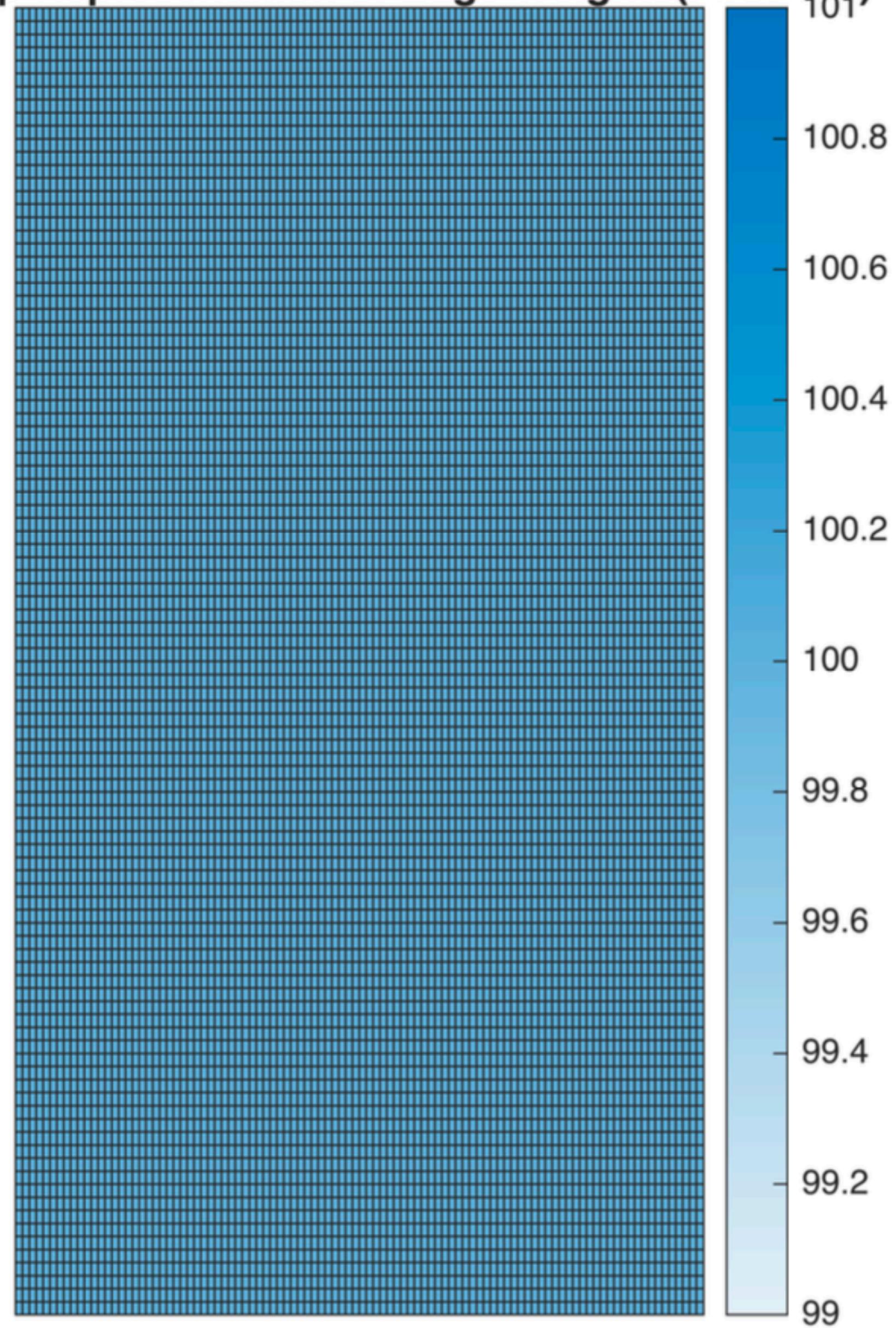
## Assumptions

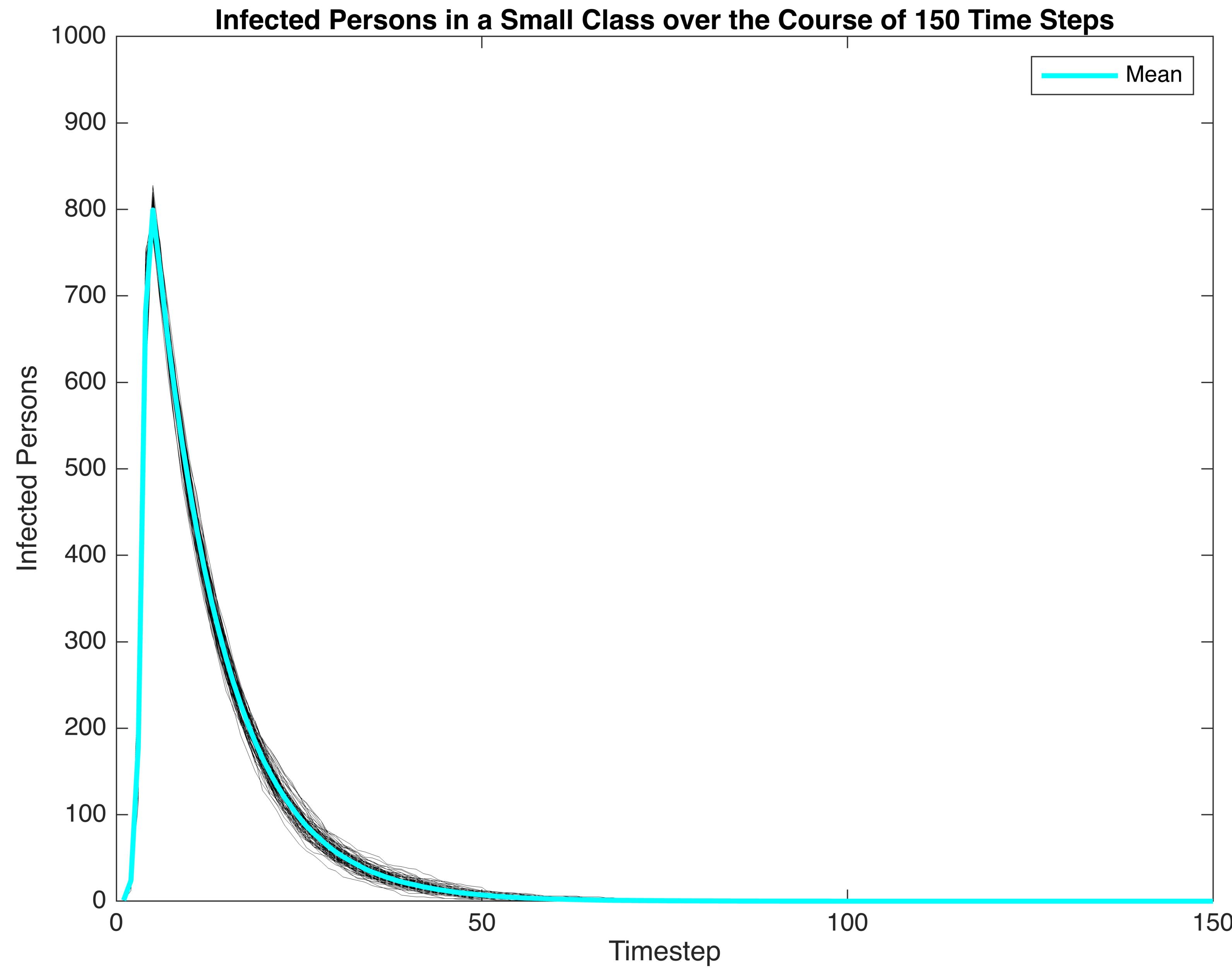
- Smaller class sizes promote stronger connections due to **interactive teaching styles**.
- **Complete interconnectedness** —> might not hold in larger colleges.
- **Equal connectivity** is assumed within each class.
- **Class sizes are assumed to be the same** for all classes —> real-life class sizes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

**Small Connected Graph**

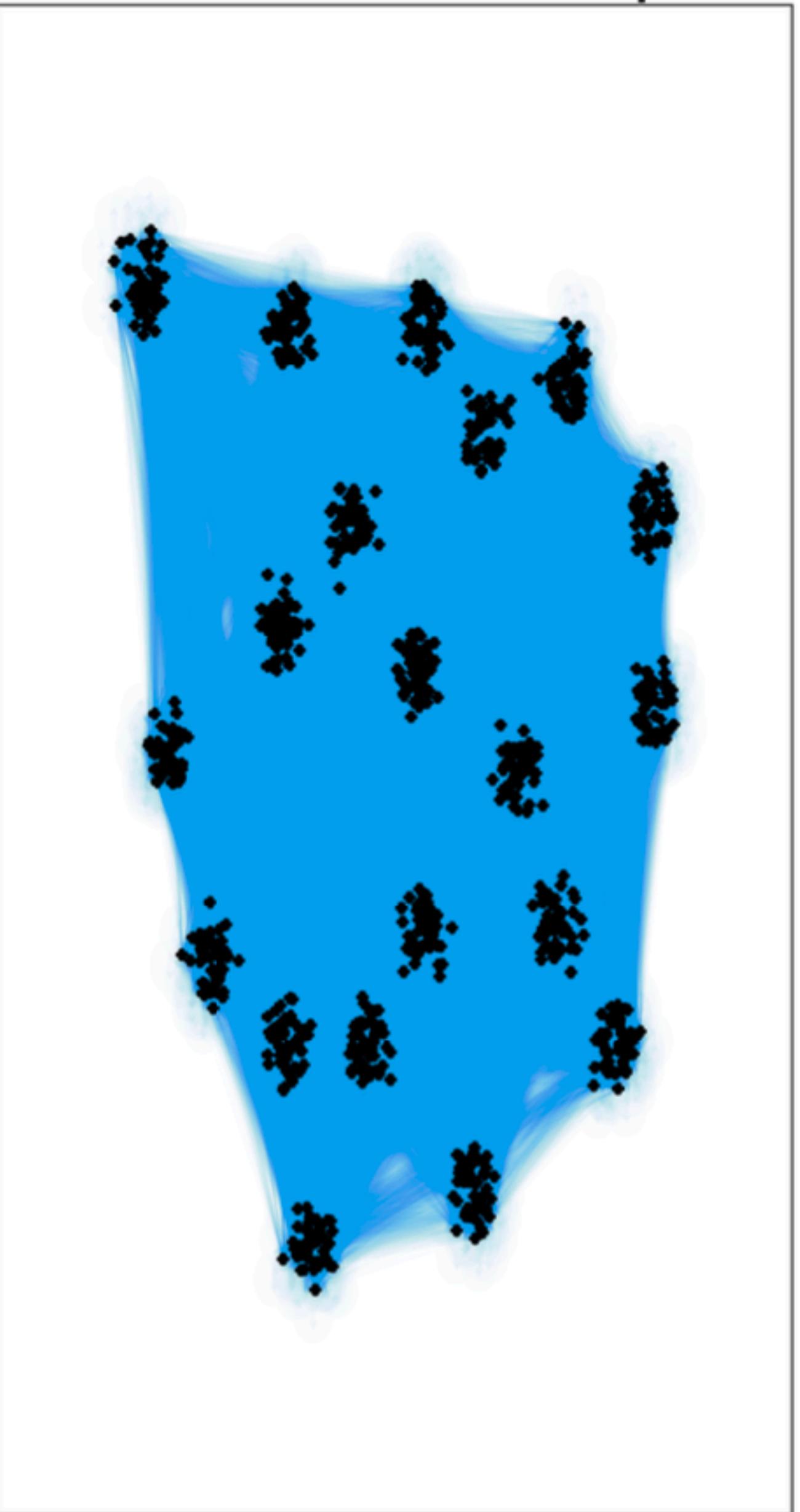


**Heatmap Representation of Edge Weights(First 100)**

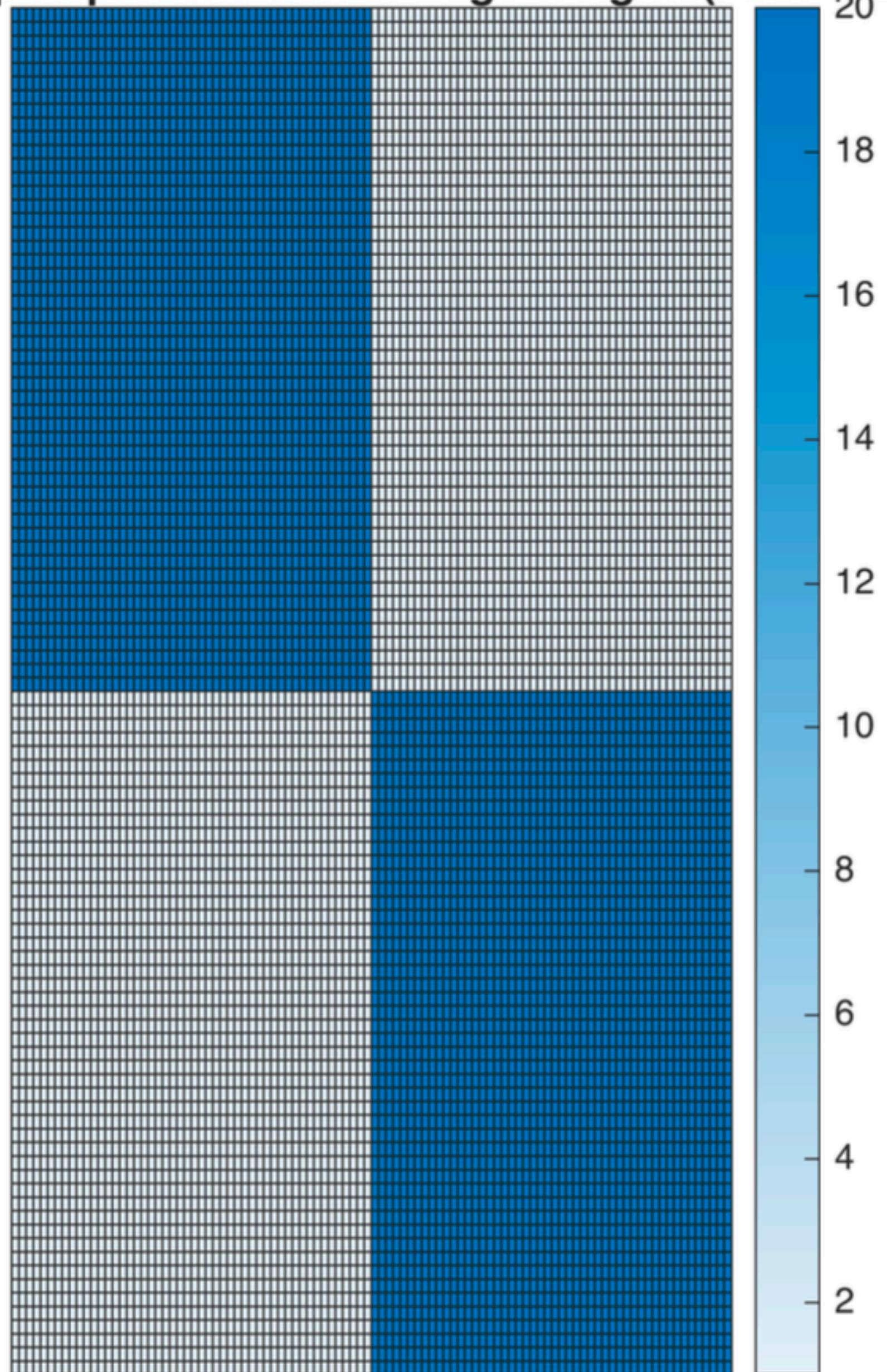


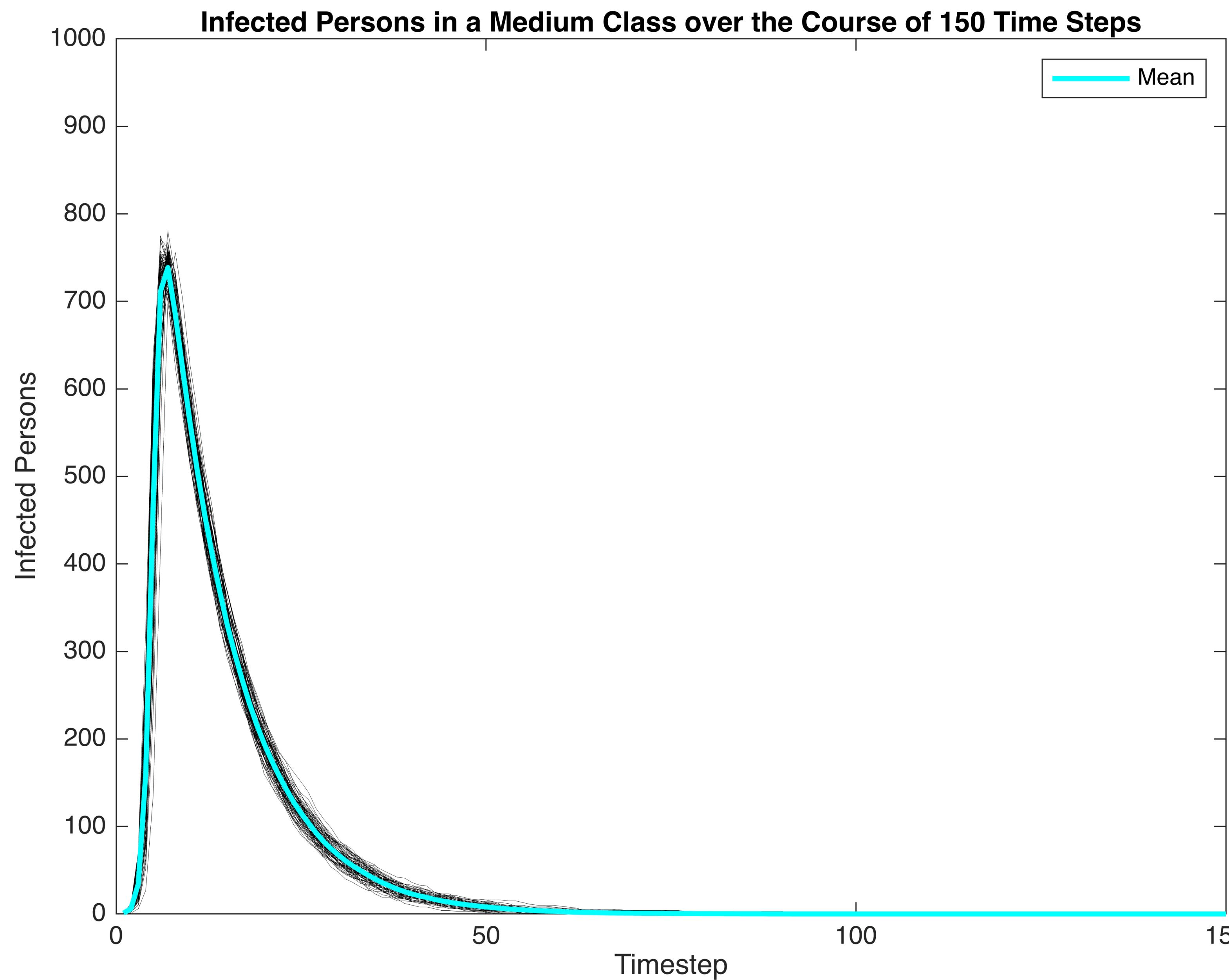


**Medium Connected Graph**

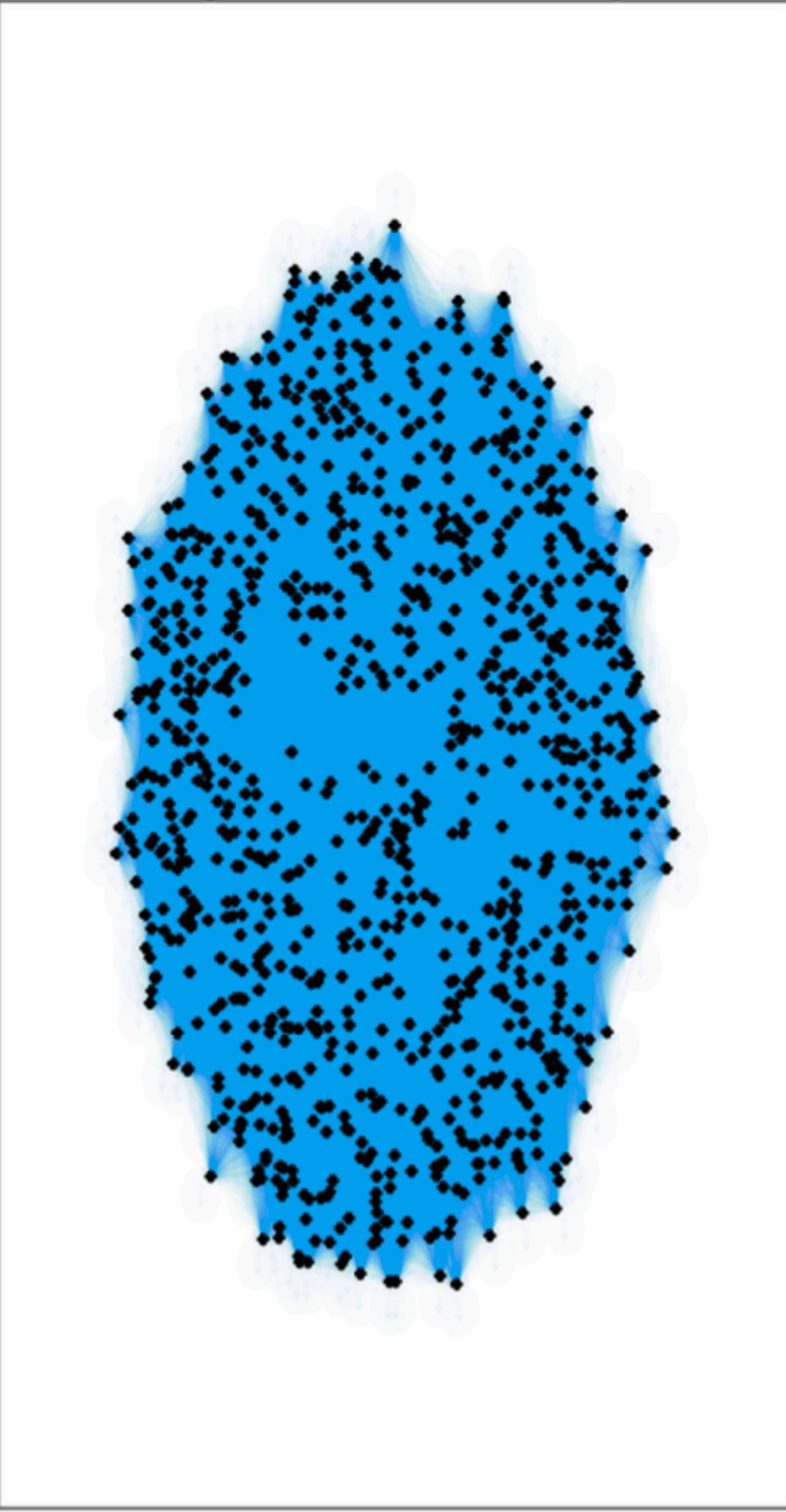


**Heatmap Representation of Edge Weights(First 100)**

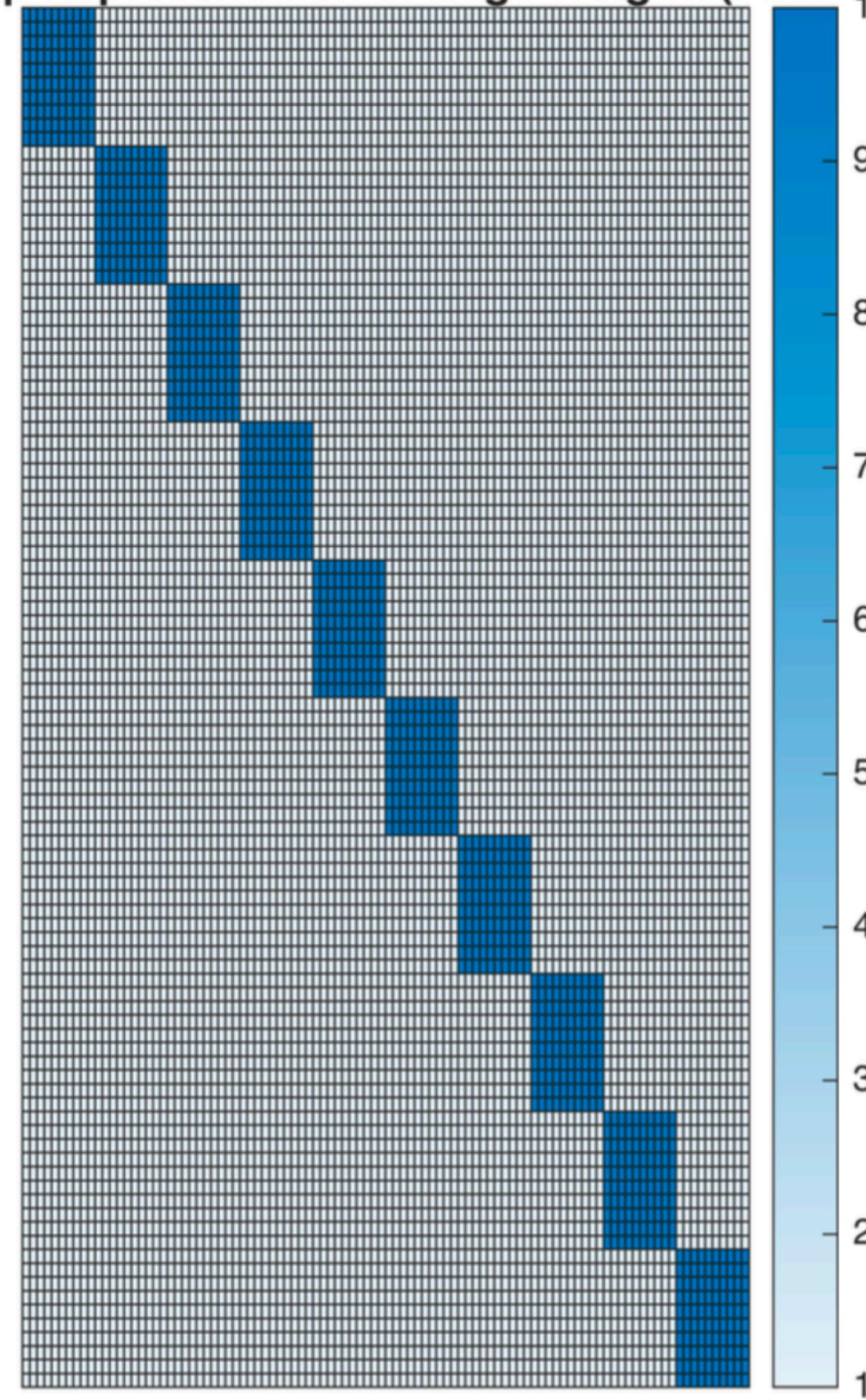


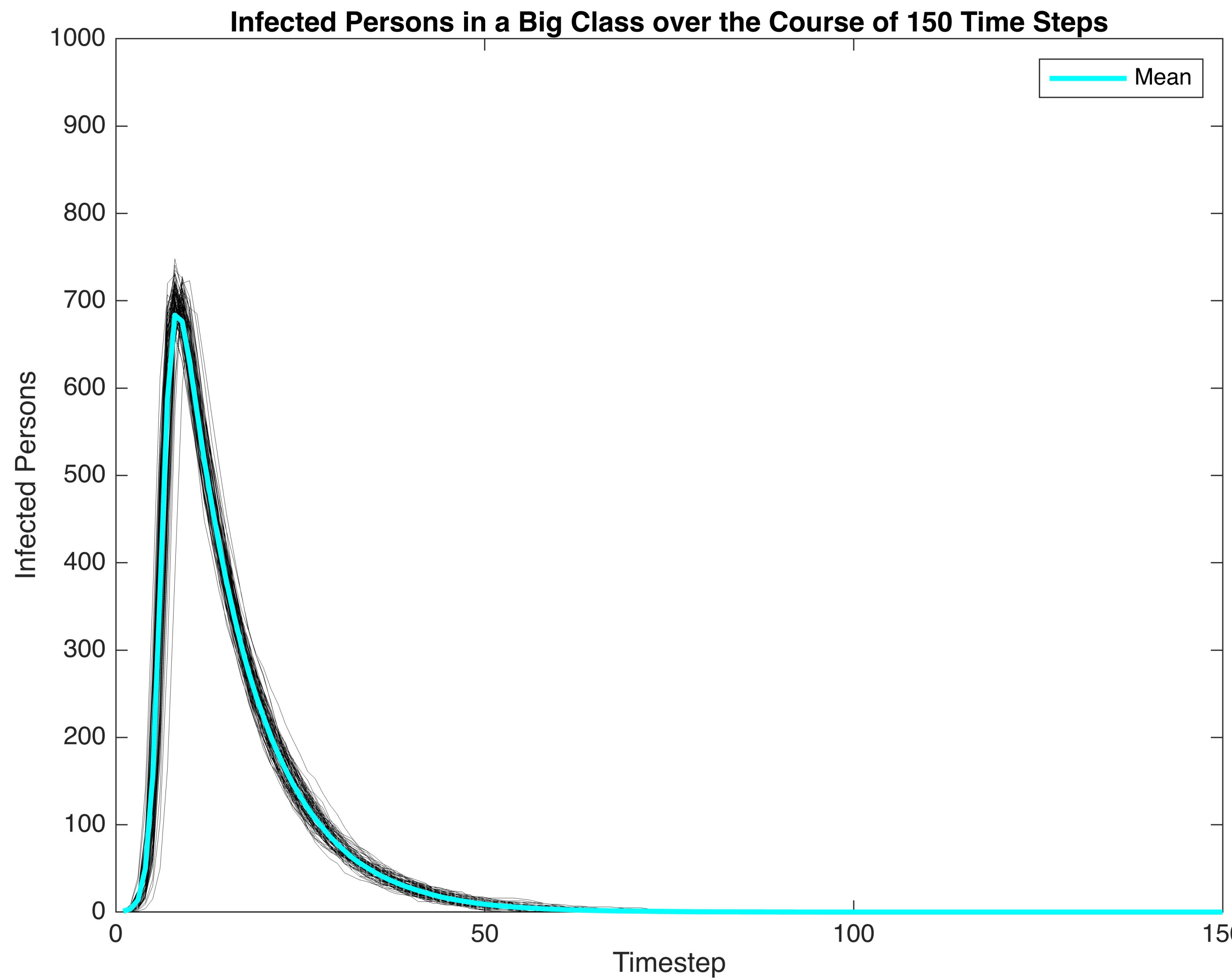


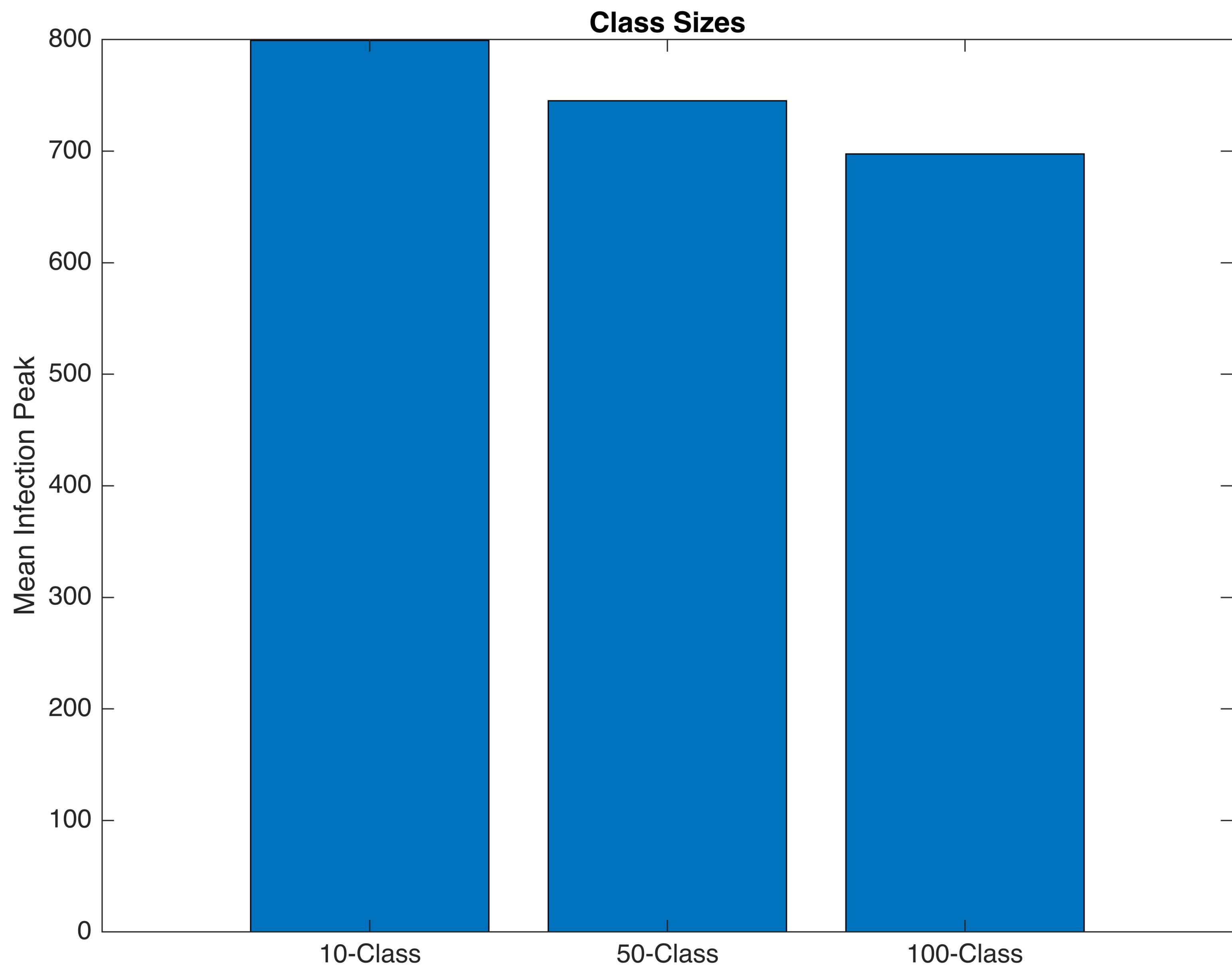
**Large Connected Graph**



**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)
```

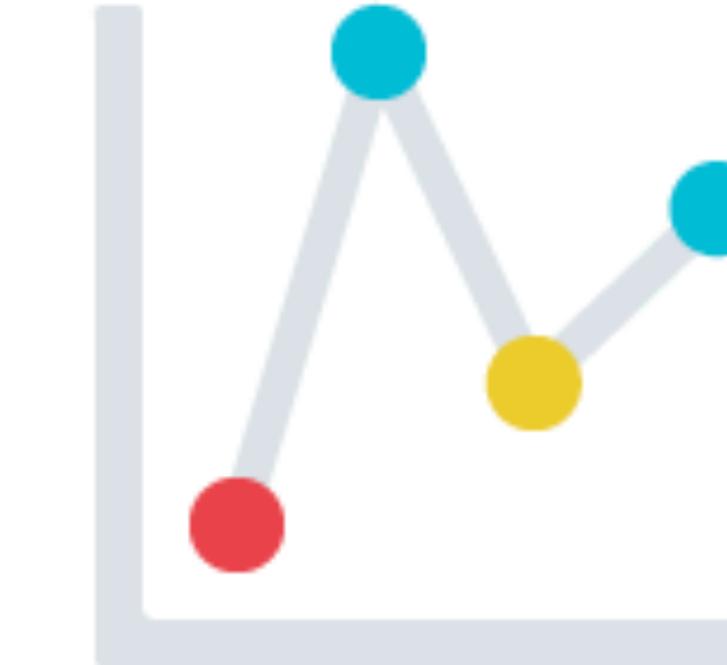
# Parameter Sweeps



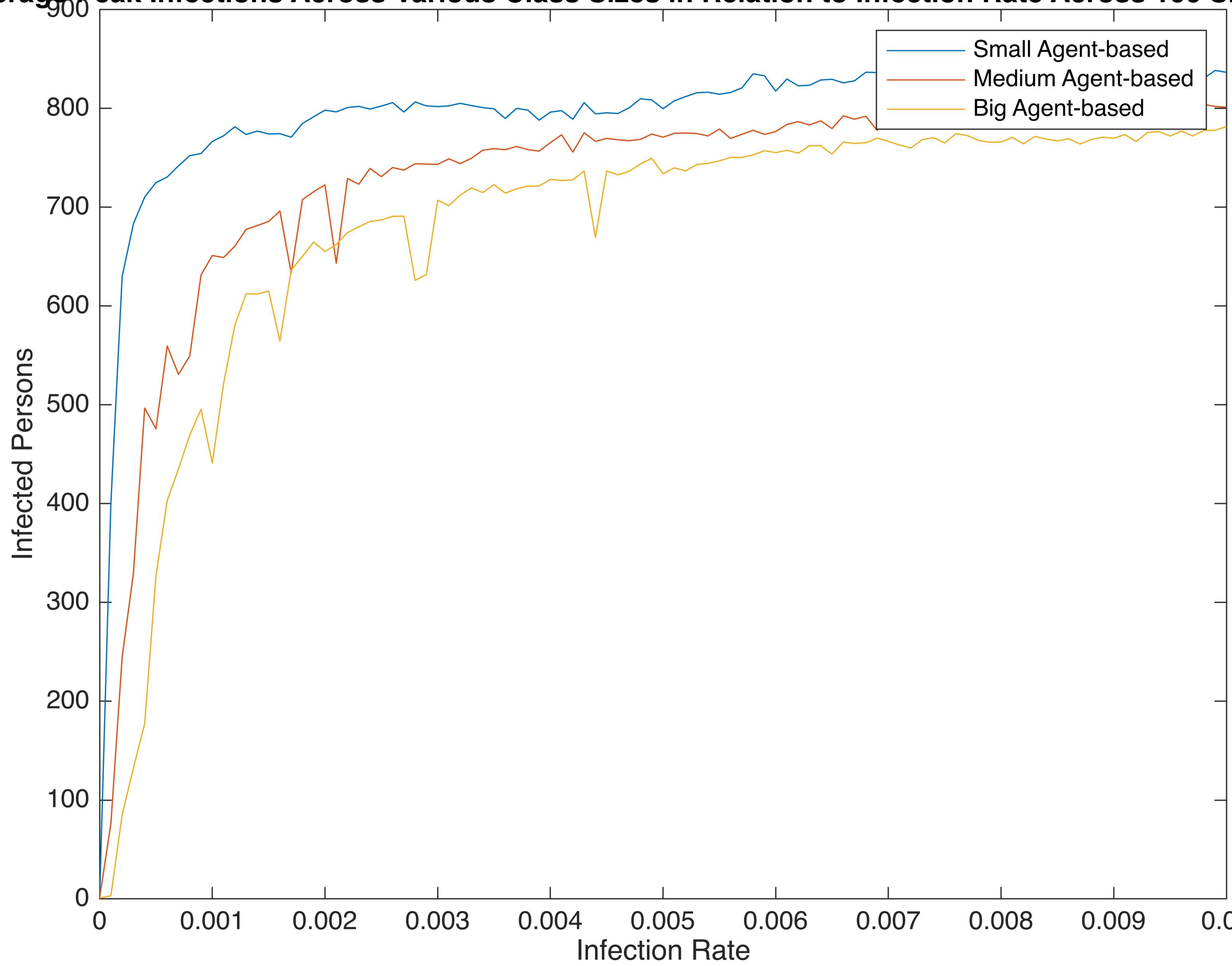
# PARAMETER SWEEPS

## Parameter Sweeps and Analysis

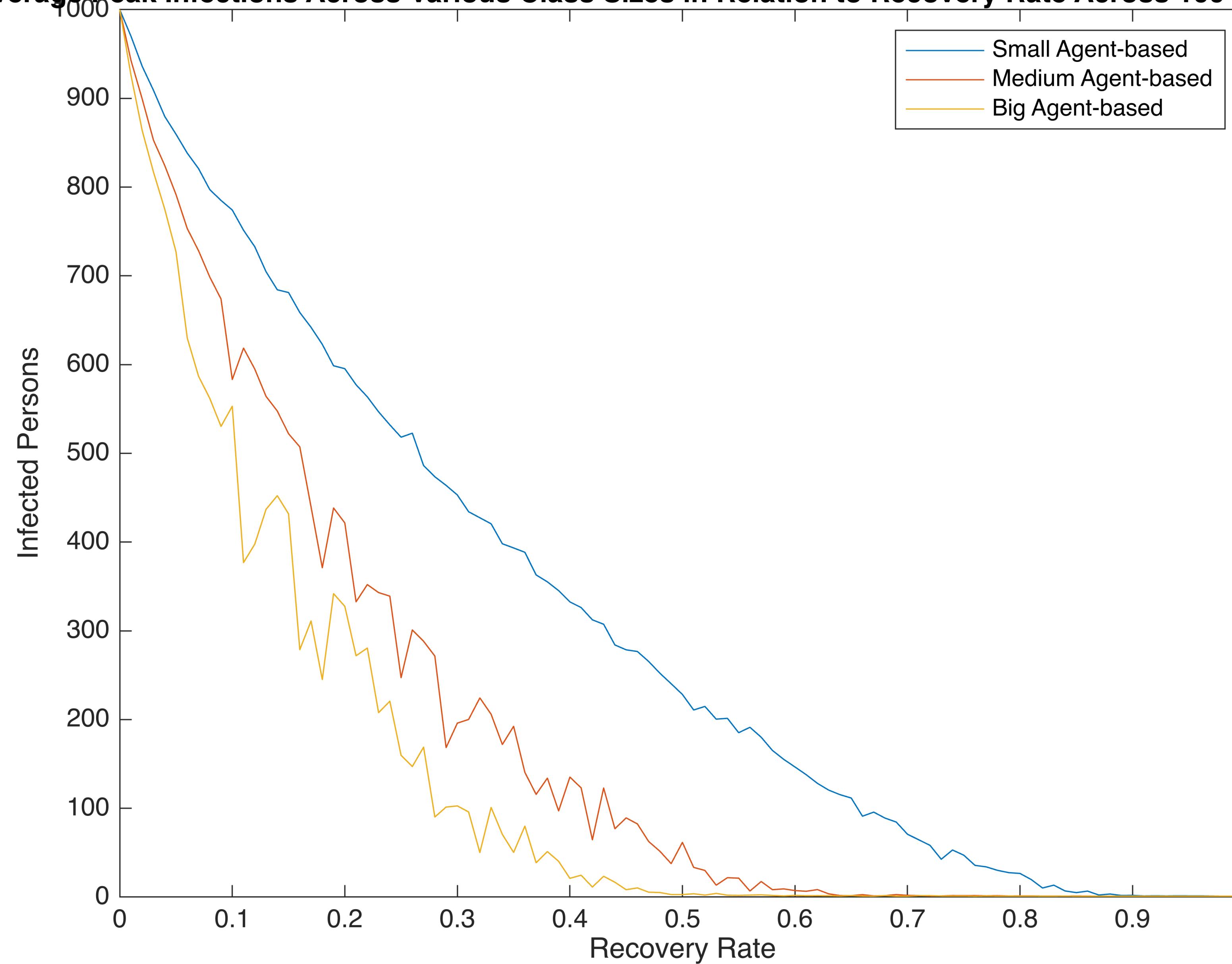
- Conducted parameter sweeps for **infection and recovery rates** across three class sizes (slides 17, 18).
- We used the metric of **mean peak infection** and calculated means based on 10 realizations due to computational limitations in MATLAB.



## 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*).

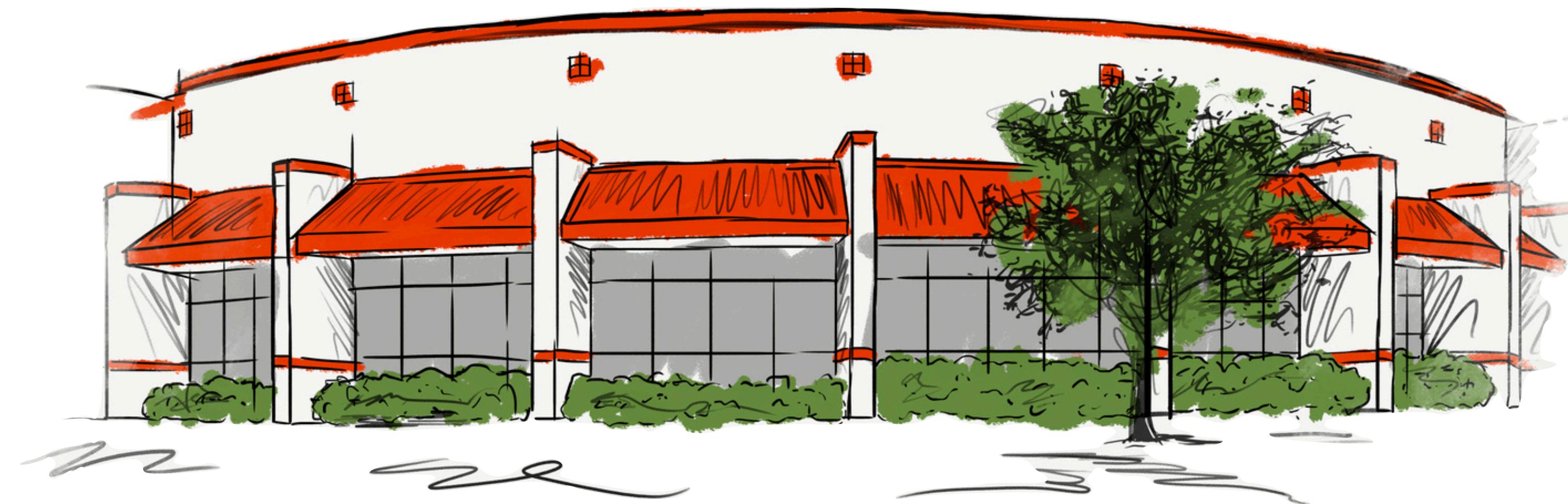
## **CONCLUSION:**

**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.

