

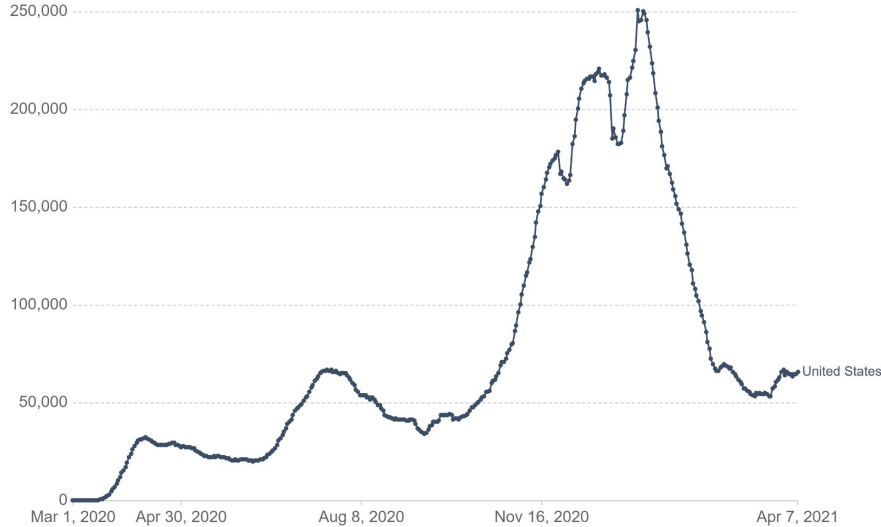
# Simulating COVID-19 Infections and Deaths with Agent-Based Modeling

Berke Nuri, Jonathan Huang

# Current State of COVID-19 in the United States

## Daily new confirmed COVID-19 cases

Shown is the rolling 7-day average. The number of confirmed cases is lower than the number of actual cases; the main reason for that is limited testing.



Source: Johns Hopkins University CSSE COVID-19 Data



## Daily new confirmed COVID-19 deaths

Shown is the rolling 7-day average. Limited testing and challenges in the attribution of the cause of death means that the number of confirmed deaths may not be an accurate count of the true number of deaths from COVID-19.



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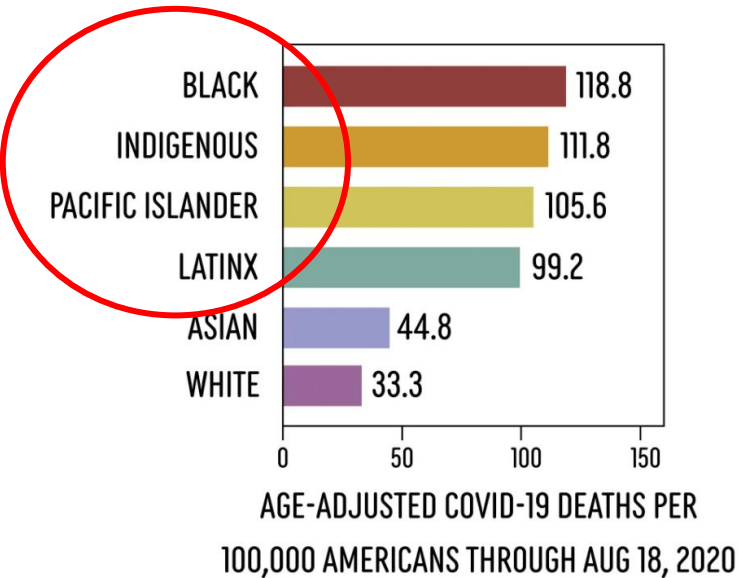
Source: Johns Hopkins University CSSE COVID-19 Data



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~ 31 million cases

~ 560,000 deaths



<https://sitn.hms.harvard.edu/flash/2020/racial-disparities-in-covid-19/>



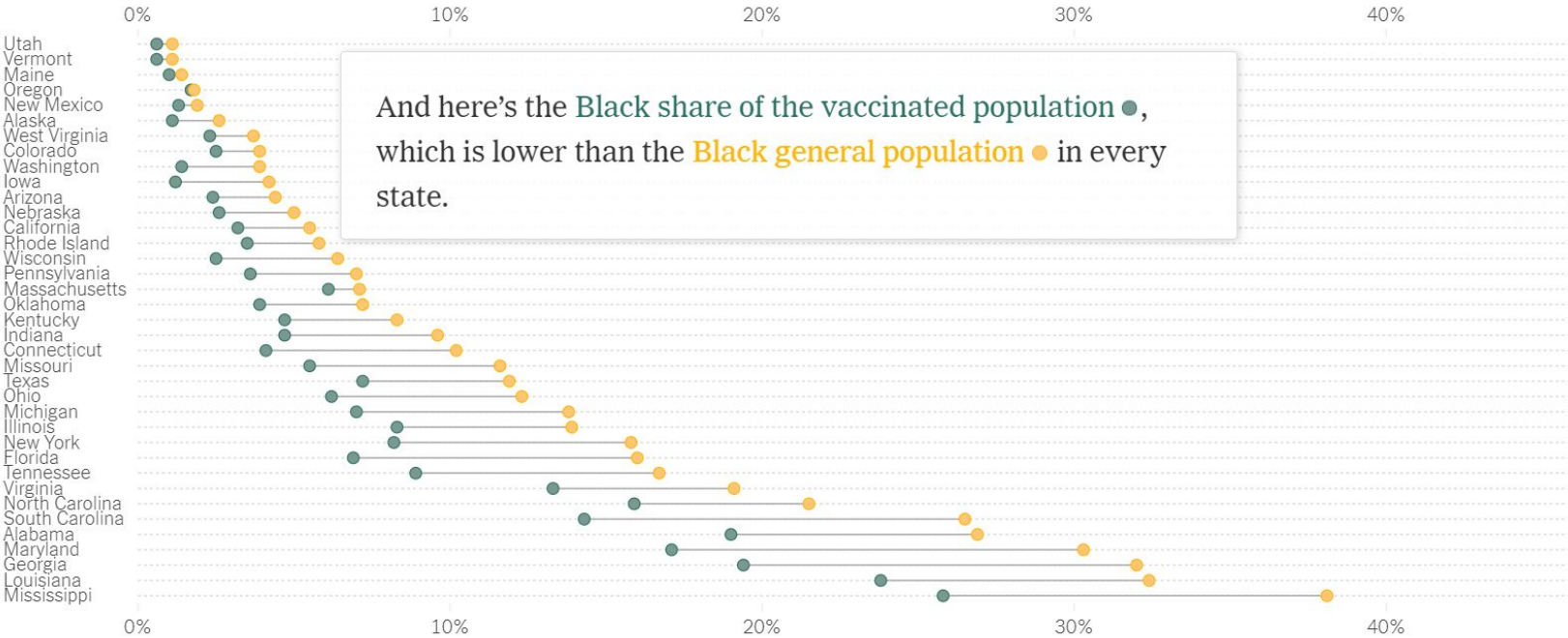
<https://www.apmresearchlab.org/covid/deaths-2020-review>

# Share of people who received at least one dose of COVID-19 vaccine

Share of the total population that received at least one vaccine dose. This may not equal the share that are fully vaccinated if the vaccine requires two doses.



Black share of the general population and the vaccinated population

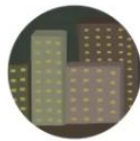


# Why is there a racial disparity?

MORE LIKELY TO:



NOT HAVE  
ACCESS TO TESTING



LIVE IN  
HIGH DENSITY



BE EXPOSED  
TO POLLUTION



HAVE A PRE-EXISTING  
CONDITION



BE AN ESSENTIAL  
WORKER



ON TOP OF

**A RACIAL BIAS  
IN HEALTHCARE**

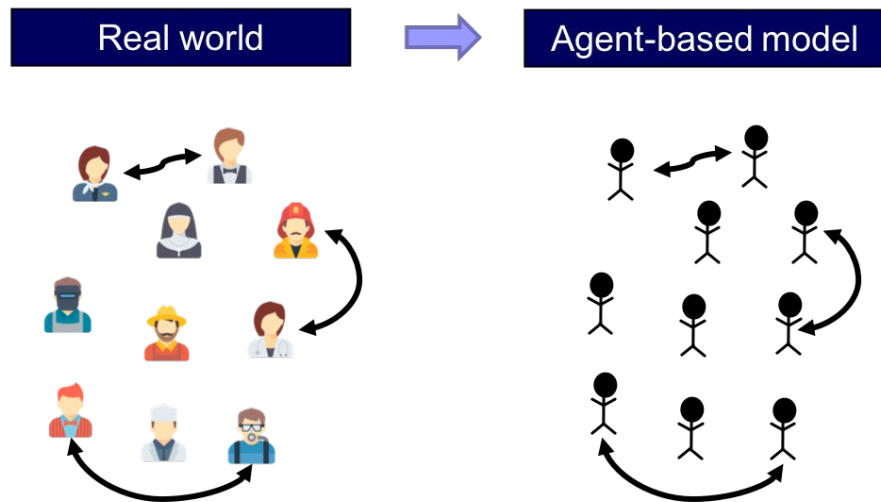
# What is an Agent-based Model?

Agents have specific characteristics

- age
- income
- geographic location
- etc.

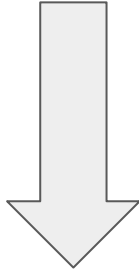
and behaviors

- likelihood to wear a mask
- social distance
- quarantine
- get vaccinated
- get tested for COVID-19
- etc.

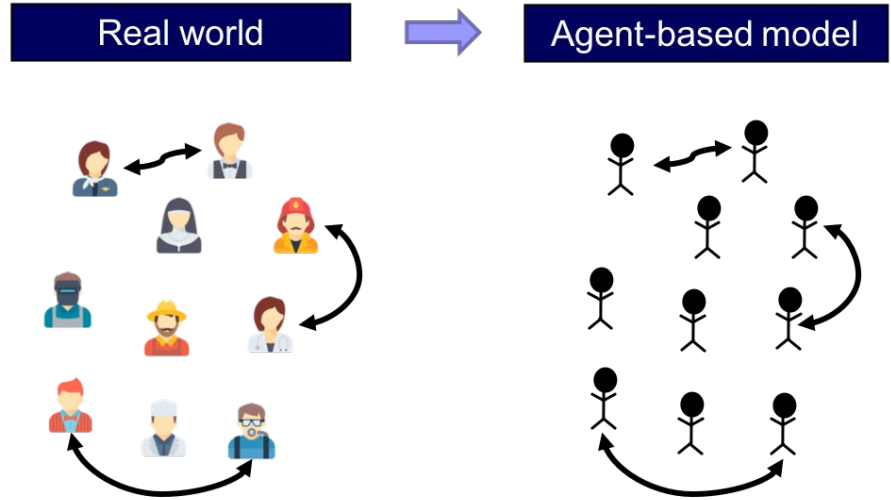


# What is an Agent-based Model?

Dynamic interactions of the many individual behaviors of these agents

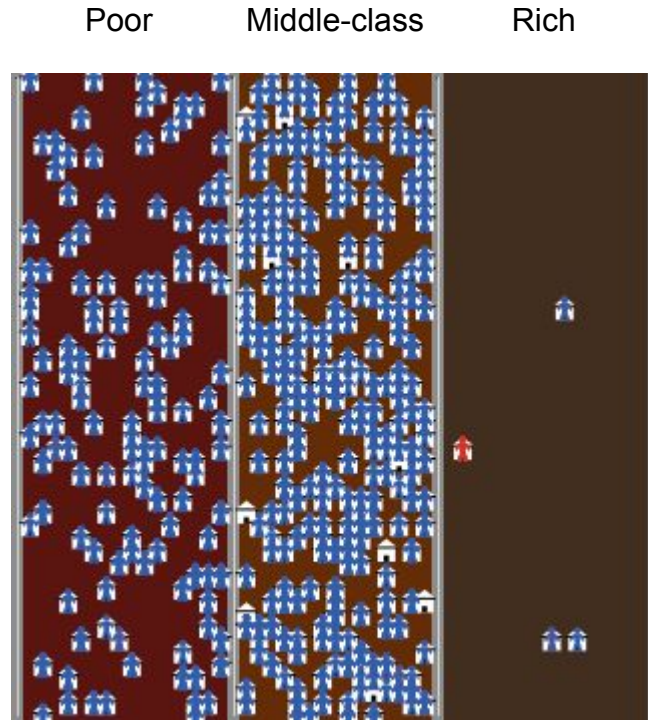


Trends and patterns of COVID-19 transmission and health outcomes

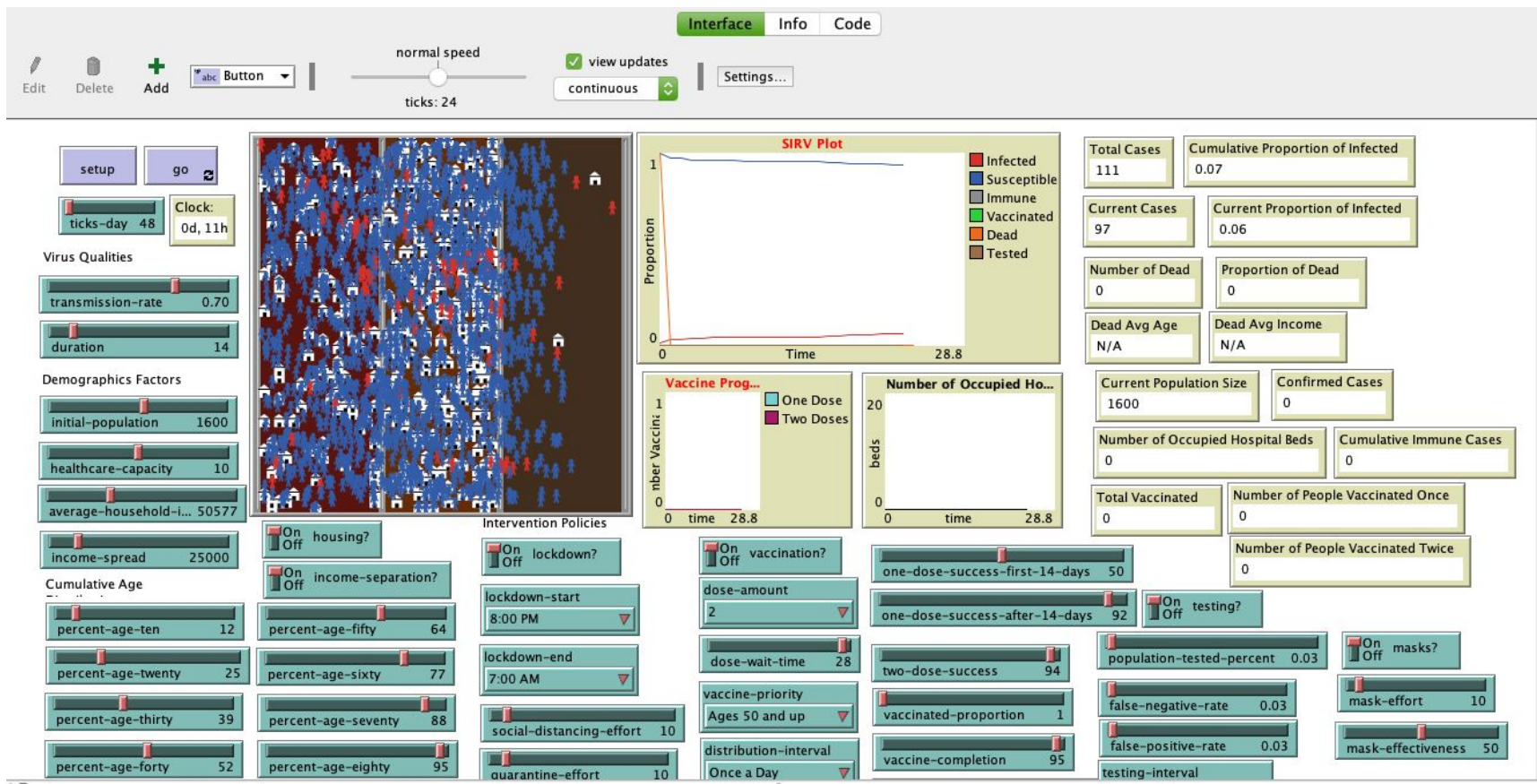




# Our NetLogo Simulation



# Our NetLogo Simulation



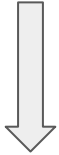
What is the effect  
of *demographic*  
*factors* on  
COVID-19 health  
outcomes?

- Age Distribution
- Household Income
- Income Disparity
- Number of Hospital Beds
- Population Density

# Three Different Communities

## Below average community

Cumulative age distribution:  
10-20-30-40-50-60-70-80  
Average Income: \$30,577  
Income gap: \$30,000  
Healthcare capacity: 5  
Population density: 2000



**Older** Population  
**Lower** Average Income  
**Higher** Income Gap  
**Lower** Healthcare Capacity  
**Higher** Population Density

## Average community

Cumulative age distribution:  
12-25-39-52-64-77-88-95  
Average Income: \$50,577  
Income gap: \$25,000  
Healthcare capacity: 10  
Population density: 1600

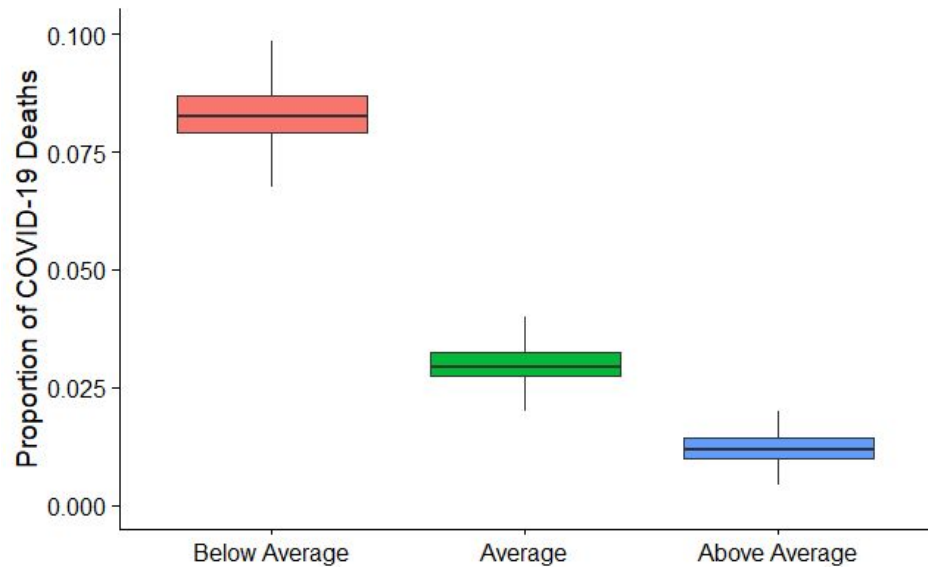
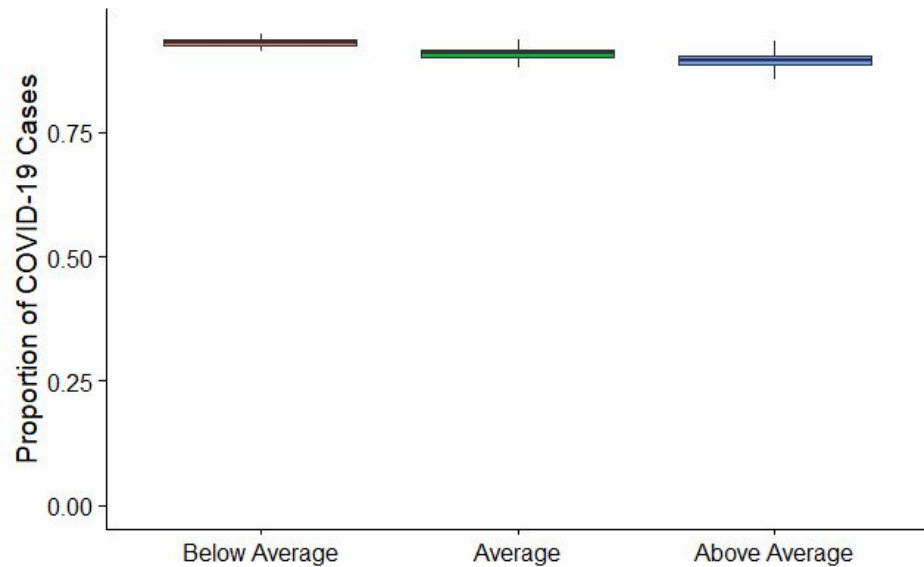
## Above average community:

Cumulative age distribution:  
30-40-50-60-70-80-90-100  
Average Income: \$70,577  
Income gap: \$20,000  
Healthcare capacity: 15  
Population density: 1200



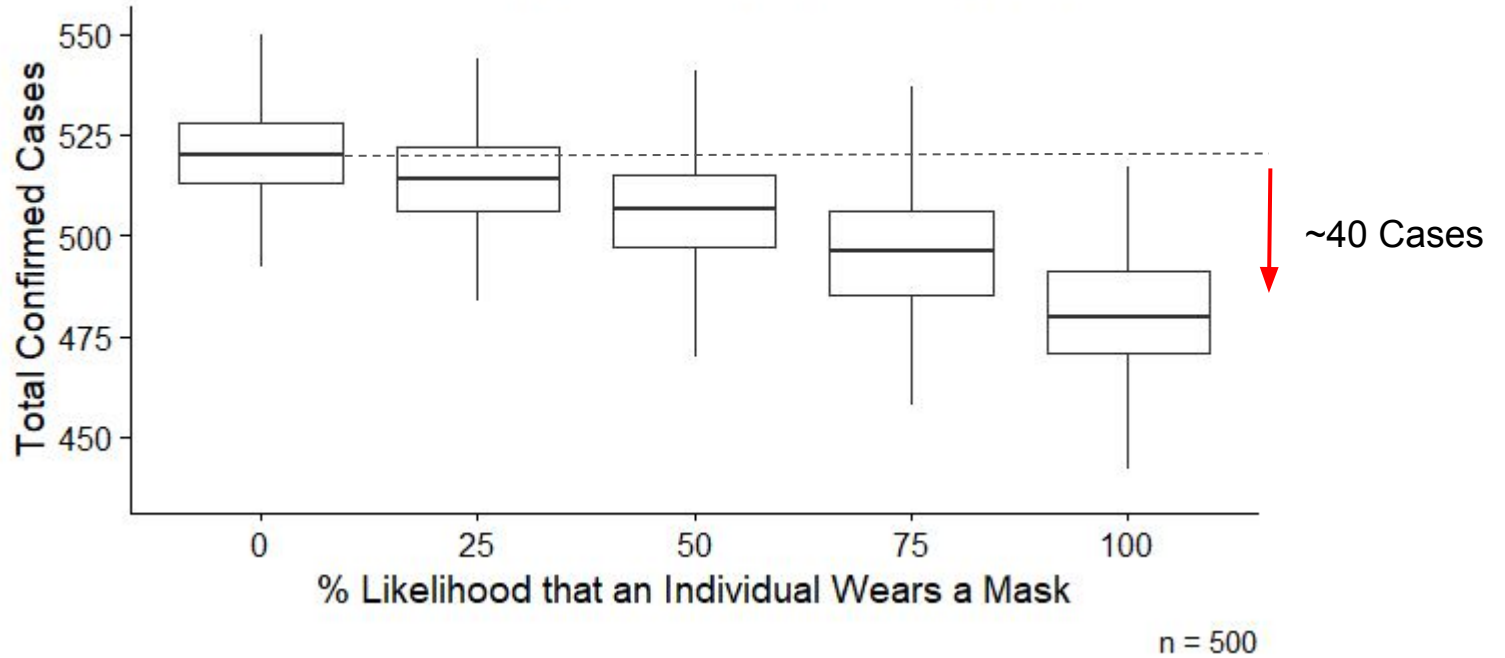
**Younger** Population  
**Higher** Average Income  
**Lower** Income Gap  
**Higher** Healthcare Capacity  
**Lower** Population Density

# Demographic factors

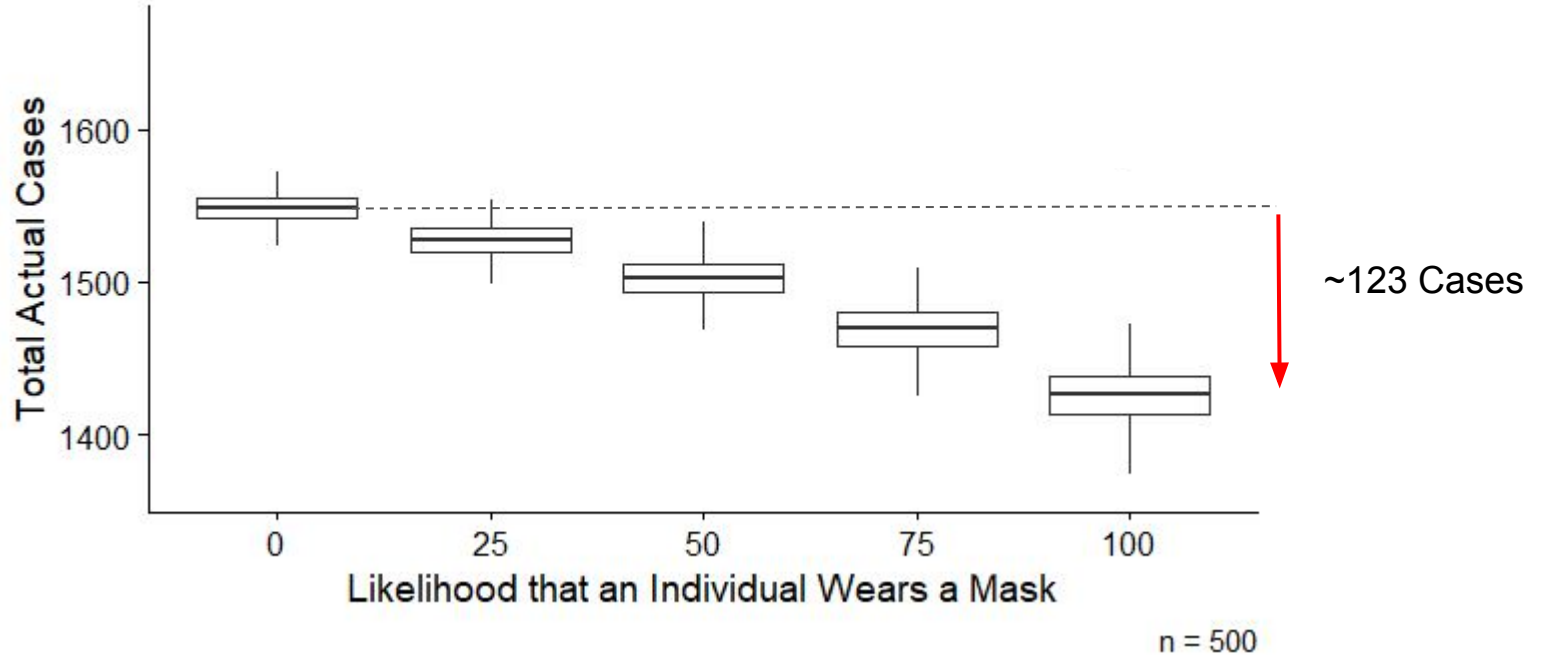


What is the effect of  
*wearing a mask* on  
COVID-19 health  
outcomes?

## Effect of Mask Wearing Behaviors on Number of Total Confirmed Cases

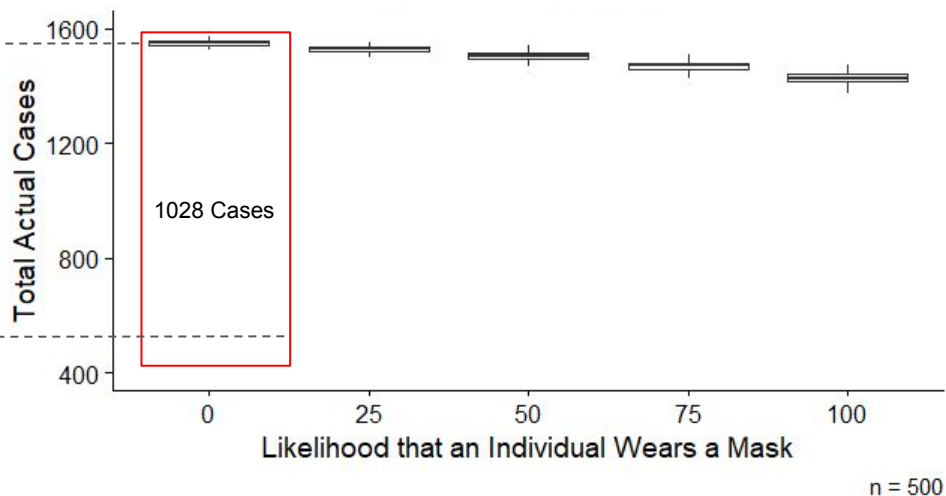
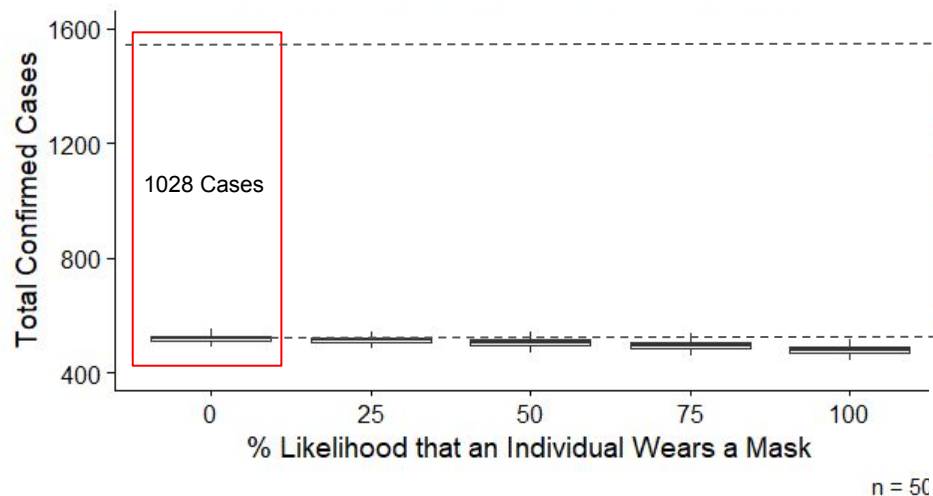


## Effect of Mask Wearing Behaviors on Number of Total Confirmed Cases

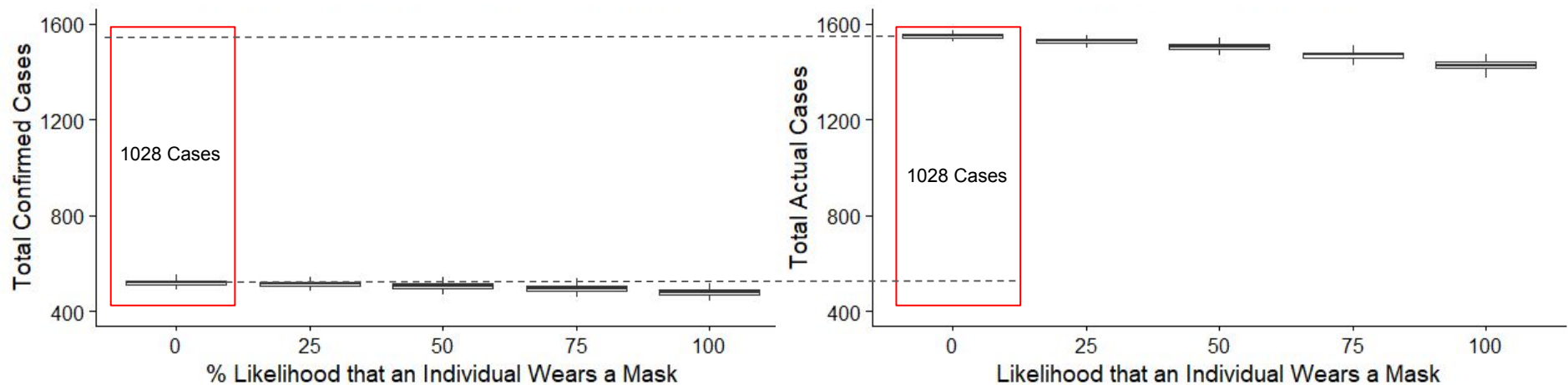




Without testing, we underestimate the number of cases by 1028 cases



Without testing, we underestimate the effectiveness of wearing a mask



~40 Cases

~123 Cases

# Summary

1. Demographic factors of a community influence COVID-19 outcomes
  - Age Distribution
  - Household Income
  - Income Disparity
  - Number of Hospital Beds
  - Population Density
  
2. Without sufficient testing, we underestimate
  - true number of COVID-19 cases
  - the importance of wearing a mask

# Future Questions

- What is the bare minimum that policy makers need to do to curb COVID-19?
- What is the most efficient way to vaccinate to minimize hospitalizations and deaths?
- How should demographic factors of a community influence policy interventions for COVID-19?

# Acknowledgements



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Research Grants | COVID-19 & Racism

**STUDENTS RESPONDING  
TO TWO PANDEMICS**