TRUST AND CONTAGION

An Agent-based Modeling (ABM) Approach in Exploring the Impact of Trust in Science, Government & Community Leaders on the Adoption of Vaccination and the Dynamics of a Vaccine-preventable Disease Outbreak

Group 3 IPSS 2023

David Kerkmann, Sascha Korf, Wan Naszeerah, Marwa Suraj

Special thanks to Michael Mäs

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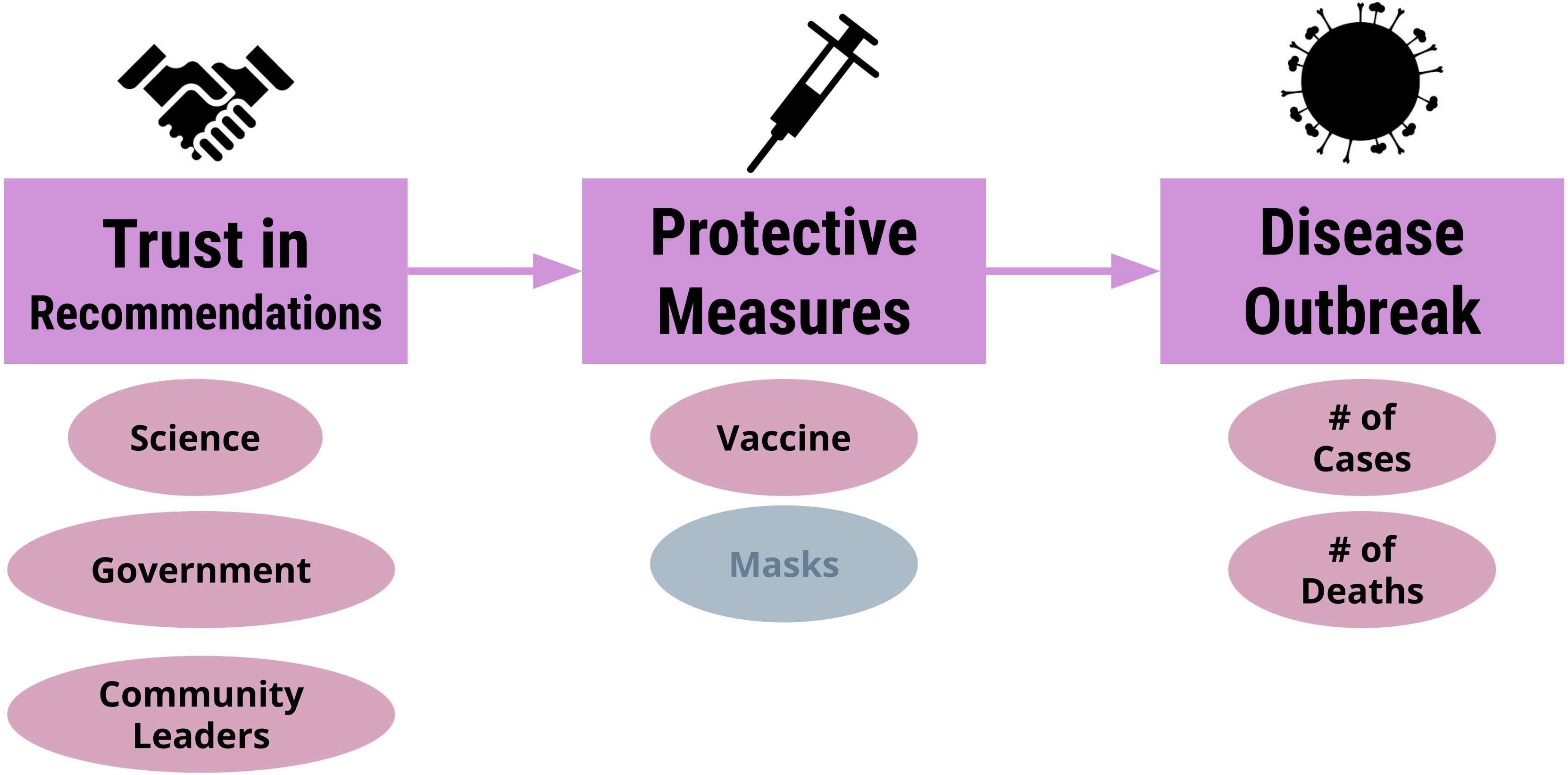
Background



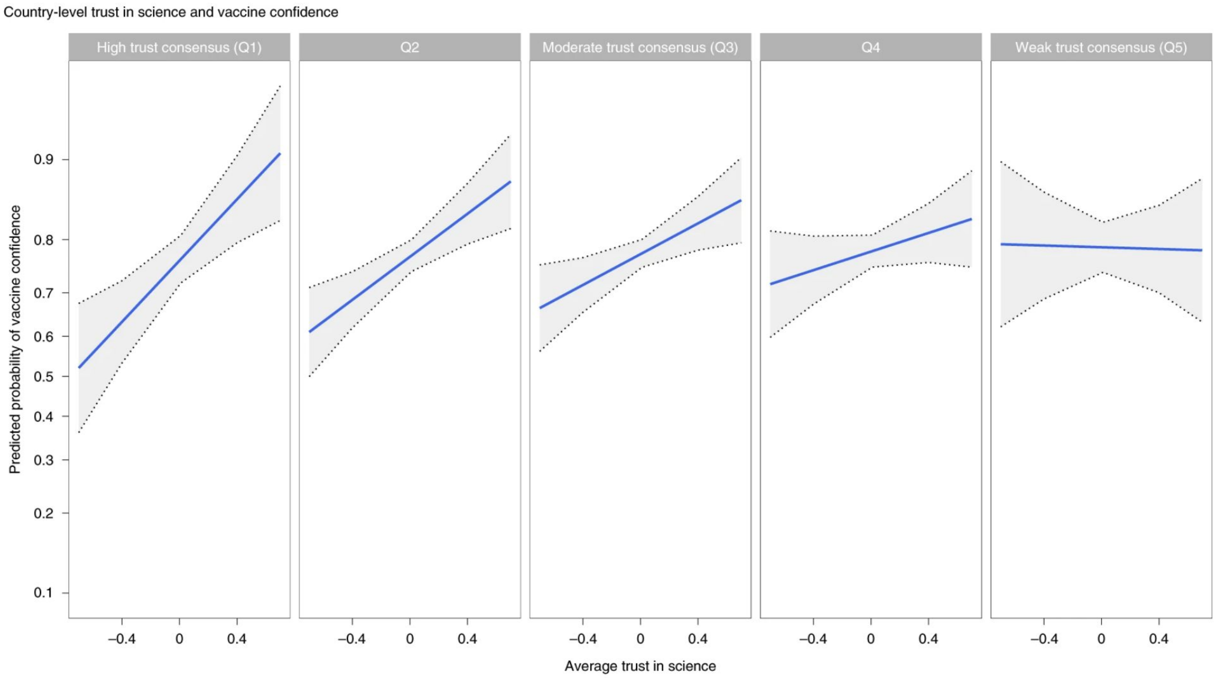
Trust in Recommendations
Protective Measures
Disease Outbreak
Science
Government
Community Leaders
Vaccine
Masks
# of Cases
# of Deaths

Trust in Recommendations

Science

Government

Community Leaders



In countries with a high level of consensus regarding the trustworthiness of science and scientists, the positive correlation between trust in science and vaccine confidence is stronger than it is in comparable countries where the level of social consensus is weaker.

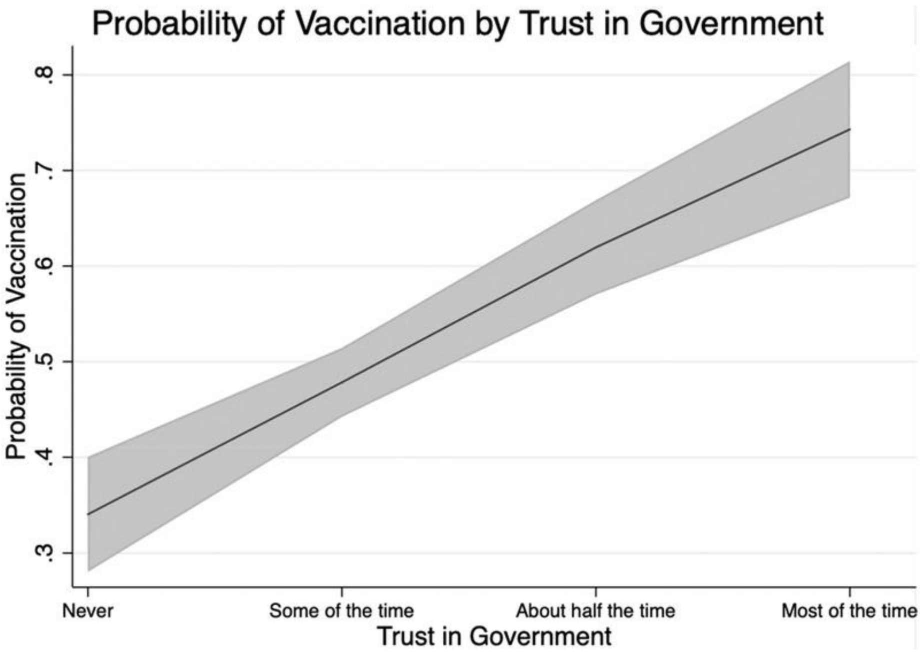
Sturgis et al, 2021

Trust in Recommendations

Science

Government

Community Leaders



People with high levels of trust in government are more likely to have received a COVID-19 vaccination than those with low levels of trust in government.

Viskupič et al, 2022

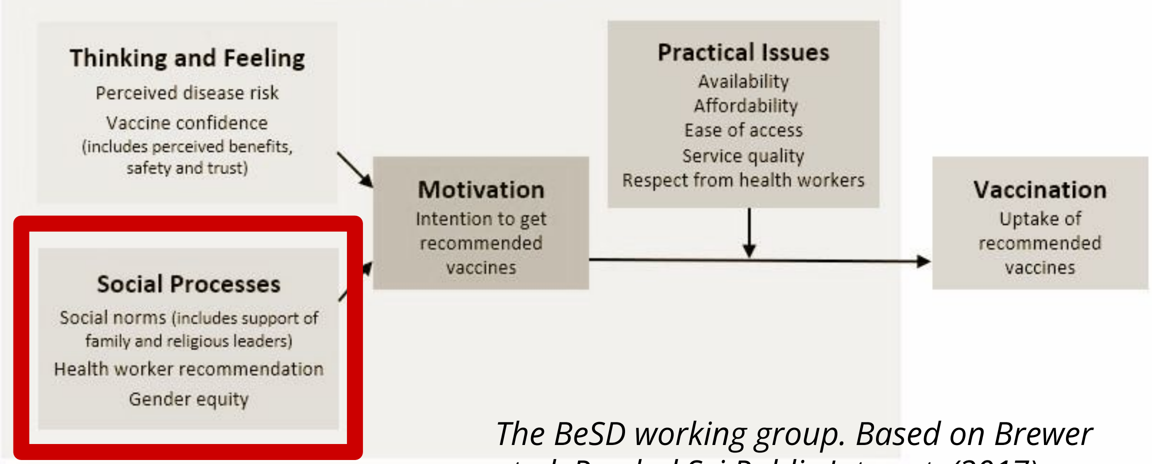
Trust in Recommendations

Science

Government

Community Leaders

The *WHO behavioural and social drivers of vaccination framework*



The BeSD working group. Based on Brewer et al. Psychol Sci Public Interest. (2017).

Messages shared by an external figure like a government spokesperson may be less accessed or trusted and therefore have less impact than messages shared by a known individual from within a particular community.

Kaufman et al, 2022

Problem Statement

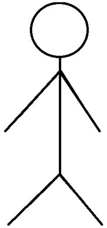
Trust plays an important role in shaping the pandemic. But, trust is not a straightforward, tangible concept:

- *"Trust" is a very nuanced social process: the confidence that a person or group of people has in the reliability of another person or group.*
- *"Trust" in different entities or institutions vary in terms of its influence on social processes at individual and societal levels.*

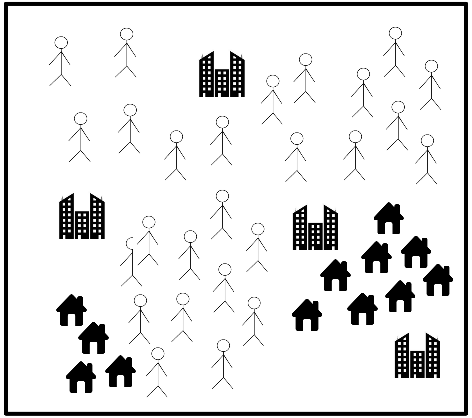
Main Research Question

How do **trust in science, government and community leaders** play a role in shaping the dynamics of a vaccine-preventable disease outbreak in a city-level population?

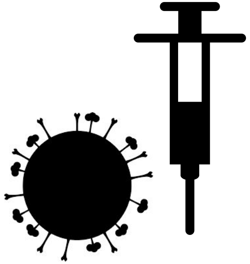
Methodology (Part 1: Defining Parameters & Characteristics)



Defining the characteristics of each agent, including mobility



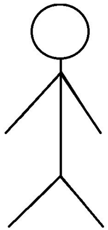
Defining the characteristics of the entire city



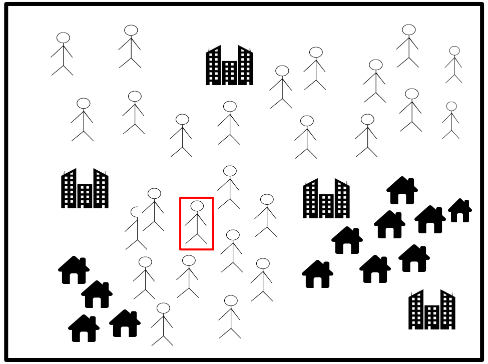
Defining the characteristics of the virus, disease outbreak, and vaccine.

Defining the parameters of trust and perceived truth (science vs. government vs. community leaders)

Methodology (Part 1: Defining Parameters & Characteristics)

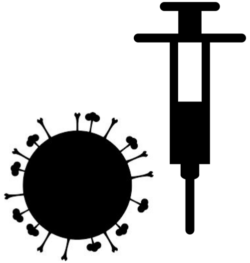


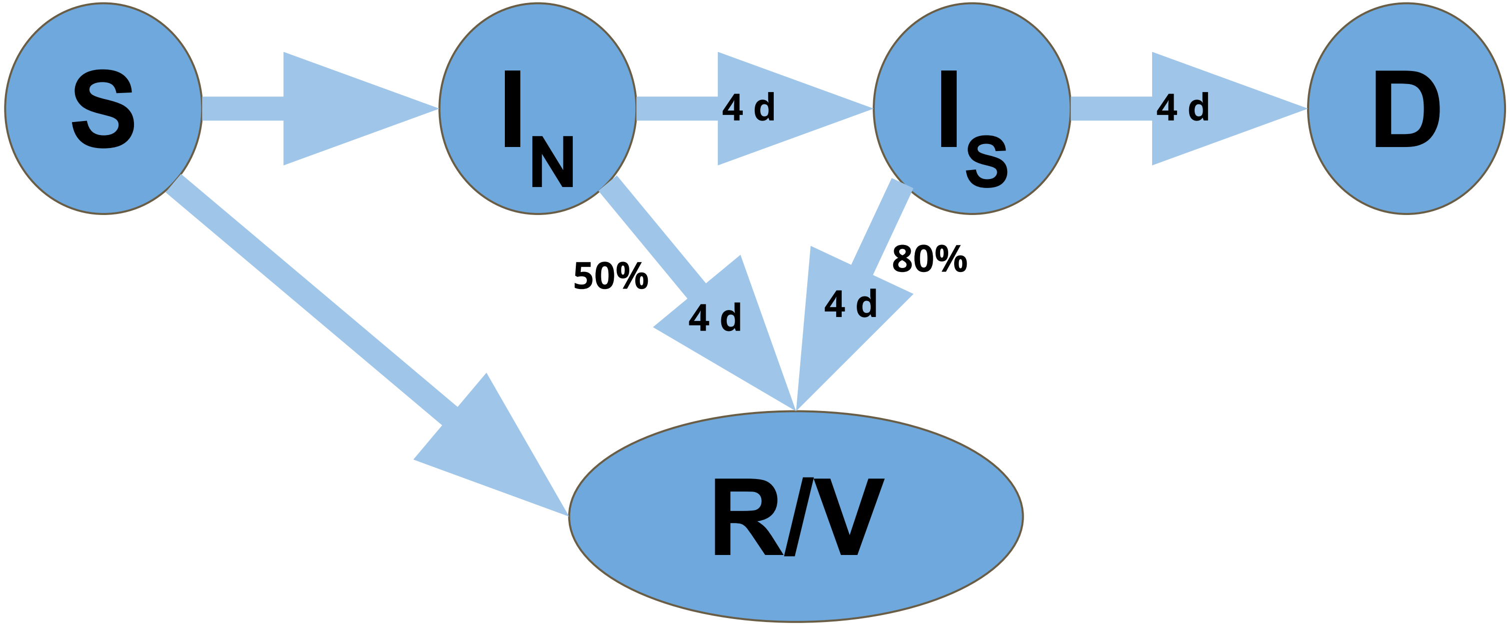
- 300 Agents
- Agents go to work 8 hours a day unless they show symptoms and spend the rest of their time home



- Homes have a capacity of 1 to 4 while workplaces have a size of 5 to 30 agents
- 2% of the people are initially infected

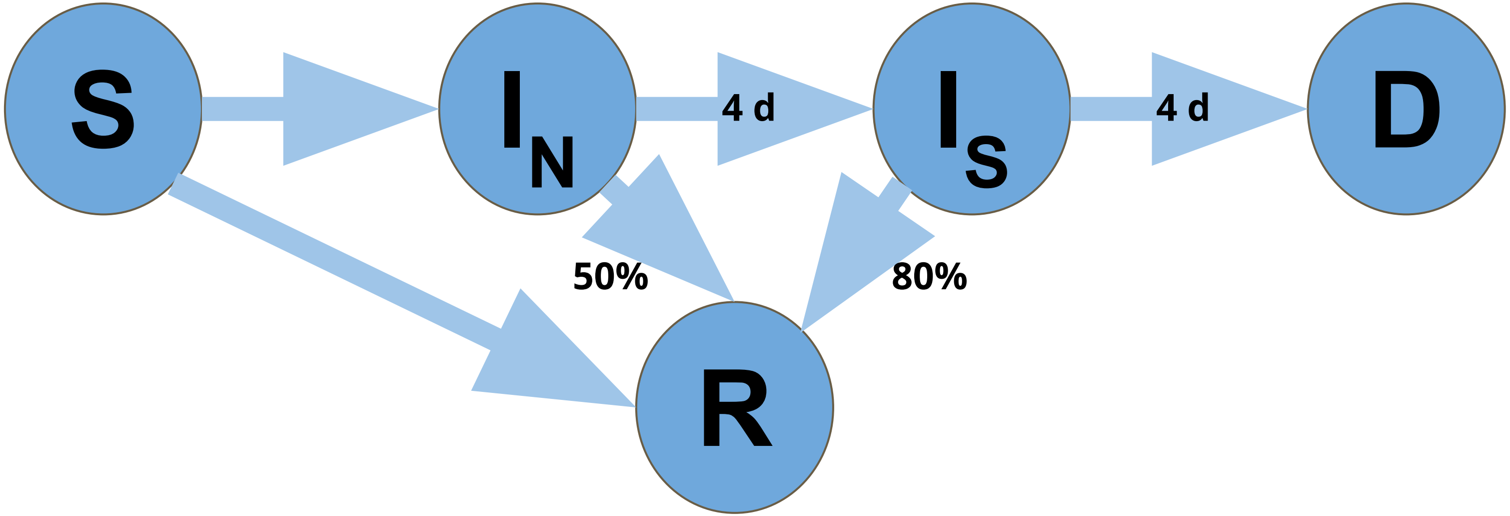
Methodology (Part 1: Defining Parameters & Characteristics)



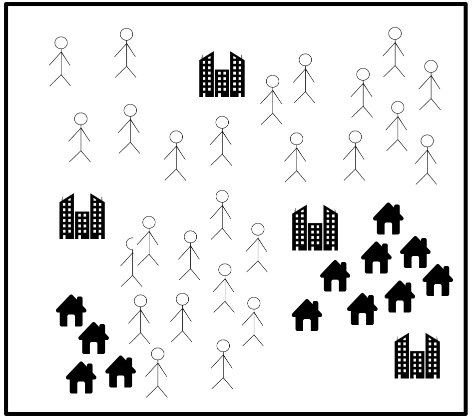


Methodology (Part 1: Defining Parameters & Characteristics)

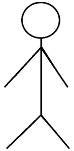
300 Agents
42 days simulation time
Agents go to work 8 hours a day and spend the rest of their time home
Homes have a capacity of 1 to 4 while Workplaces have a size of 5 to 60 agents
2% of the people are initially infected
10 runs per setup to account for uncertainty



Methodology (Part 2: Building a Feedback Loop)

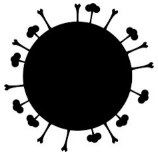


An agent's decision to accept or reject vaccine depends on:

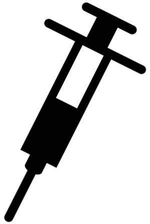


Their personal characteristics

Their trust in science, government, & community leaders

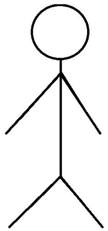


Their infection status



Their vaccination status

Methodology (Part 2: Trust system)

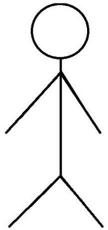


Institutions	Science	Government	Leader
Perceived truth	0.8	0.7	0
Individual trust	0.6	0.5	0.8

Decide to vaccinate if not already sick, vaccinated or recovered AND
<Perceived truth, Individual trust> is **larger** than the **threshold**

Example from above:
We vaccinate if
0.8*0.6 + 0.7*0.5 + 0*0.8 = 0.83 > threshold_vaccinate

Methodology (Part 2: Trust with R value influence)



Institutions	Science	Government	Leader
Perceived truth	0.8	0.7	0
Individual trust	0.6	0.5	0.8

threshold_vaccinate = sum(perceived_truth)/(1+threshold_influence*R)

Example from above (threshold_influence=1, R=0):
0.8*0.6 + 0.7*0.5 + 0*0.8 = 0.83 > 1.5 is False => No Vaccination

Example from above (threshold_influence=1, R=1):
0.8*0.6 + 0.7*0.5 + 0*0.8 = 0.83 > 1.5/2 = 0.75 is True => Vaccination

Methodology (Part 2: Trust changes)

Change in Trust:

(a) Influence response function:

- Opinion assimilation
- Opinion repulsion

(b) Behaviour bridge from pandemics:

- Trust in government rises if R is low and drops if R is high
- Trust in science rises if R is low, but more at the start of the pandemic

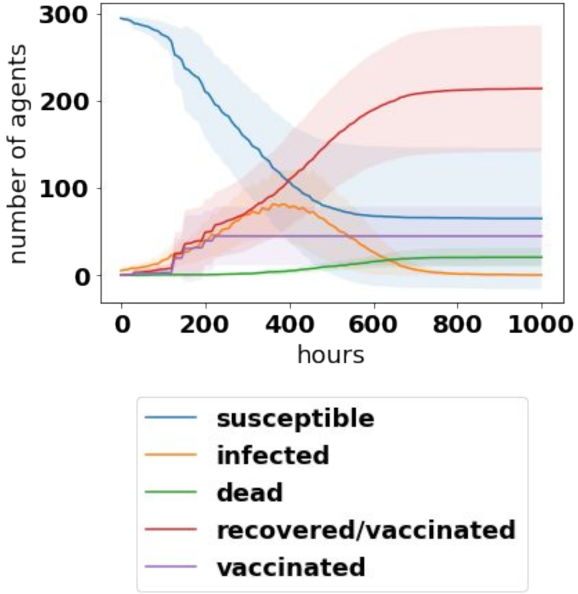
Influence controlled by a factor **trust_change_velocity**.

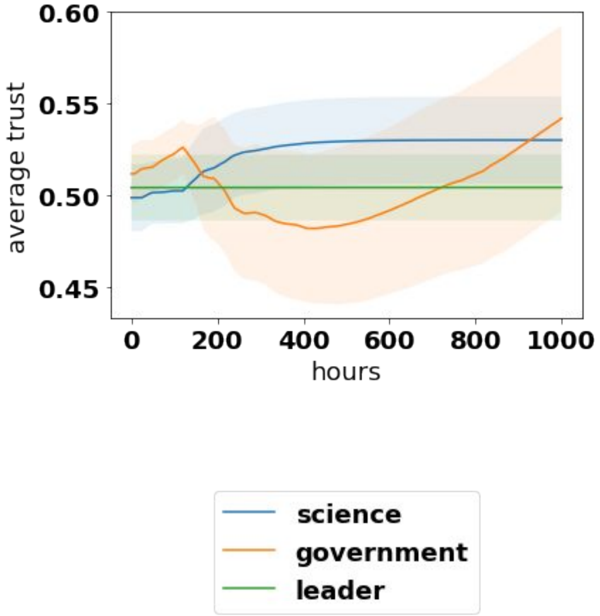
Methodology (Part 3: Testing Under Various Scenarios)

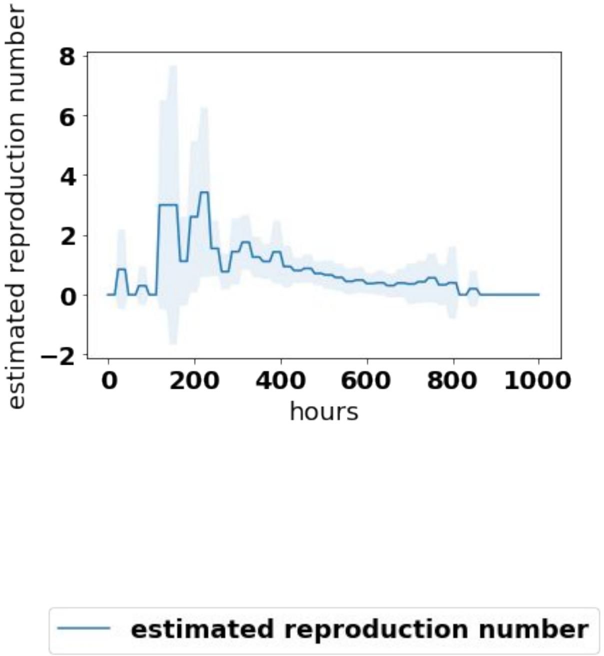
We are interested in exploring the following scenarios:

1. Base Scenario
2. Zero-trust
3. Bifurcation analysis for **trust_change_velocity**:
    Changes to infection dynamics

Results (1. Base Scenario)

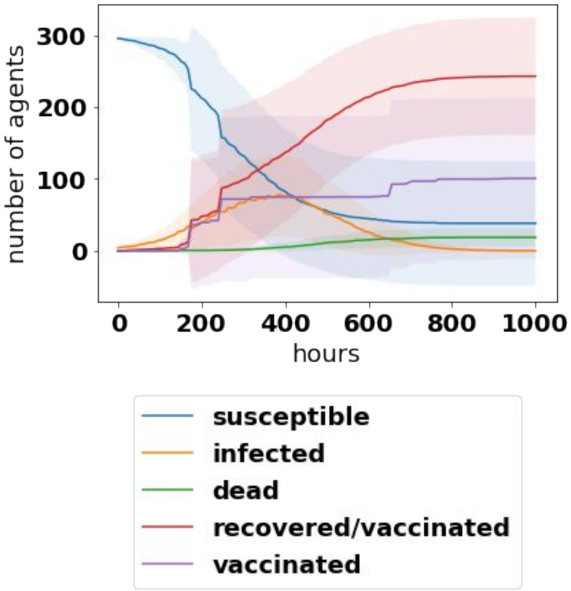


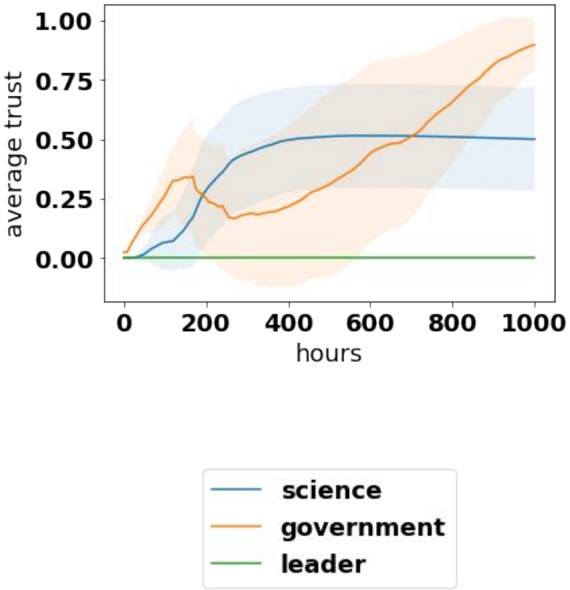


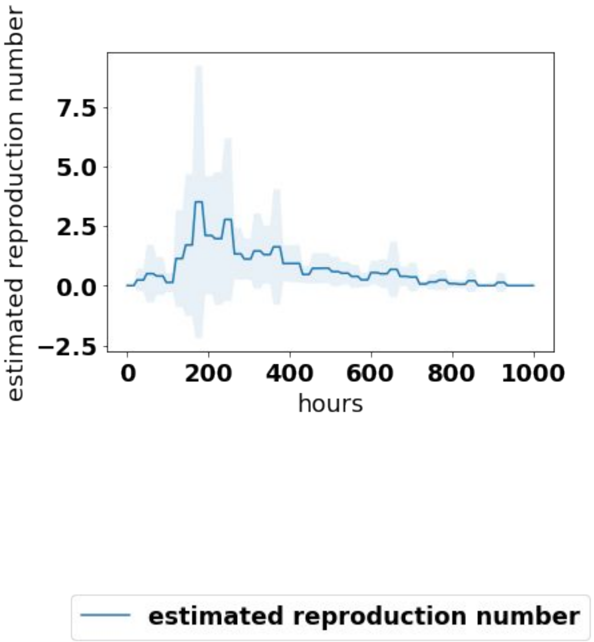



```
trust_change_velocity = 0.01/max_dt
threshold_influence = 0.05
```

Results (2. Zero-trust)

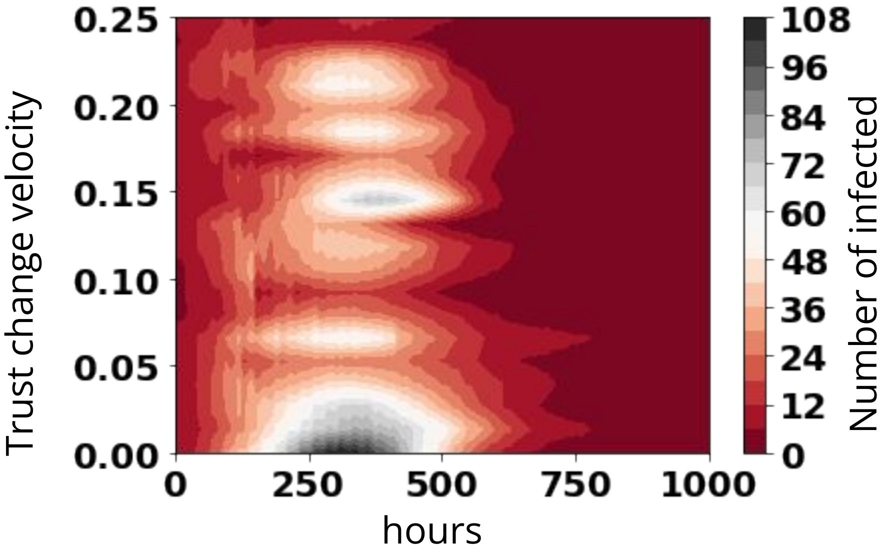




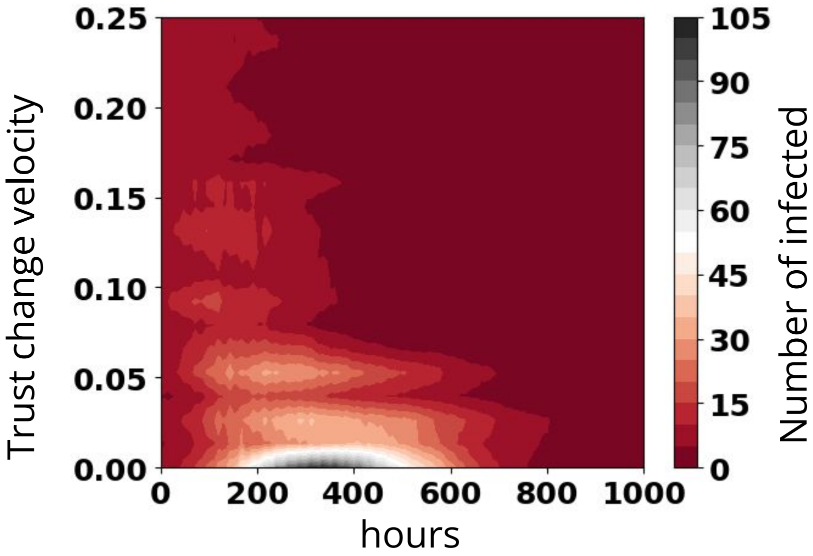



```
trust_change_velocity = 0.2/max_dt
threshold_influence = 0.2
```

Results (3. Bifurcation analysis)



Opinion assimilation



Opinion repulsion

Discussion

- To our best knowledge, **an agent-based modeling approach has not been used to demonstrate the dynamics of trust in different institutions/ entities on a vaccine-preventable outbreak**.
- Albeit limited in terms of its current capability in simulating the real world, **our model offers insights on the dynamics of trust on vaccination uptake and therefore, the severity of an outbreak.**
- Knowledge gained about the dynamics of trust in science, government and community leaders germane to protective behaviors can **aid in the creation or adaptation of interventions to combat current and future pandemics.**

Limitations

An agent-based modeling technique is not without any limitation.

- **Our model is built upon many assumptions.**
  - *For example: a single vaccine dose or a single infection provides full immunity to an individual from the disease of interest.*
- **Given resource constraints, our model ignores the role of other protective behaviors, such as mask-wearing and social distancing.**
  - *Good news: we can further develop this model by adding more parameters!*
- **The nature of trust is dynamic – it could instantaneously change in response to events at individual and societal levels.**
  - *Could we ever capture the real-life dynamics in our model? Perhaps when domain knowledge and empirical data on the dynamics of trust in different entities are available!*

Conclusion

- An agent-based modeling approach can offer useful insights on the interplay between trust, protective behaviors, and a disease outbreak.
- However, the capabilities of an agent-based model relies greatly on the availability and reliability of empirical evidence/ dataset and domain expertise (example: the psychology of trust).

Future Directions

- Increase complexity of the model
  - Add diversity of the agents
  - Improve infection dynamics, e.g. make vac. not perfect, allow for reinfection
  - Extend and improve behavior
  - Add mask-wearing and self-protective measures to the behaviors
  - Add communication network
- Add NPIs
- Add non-perfect communication
- Consider further scenarios, e.g. leader-based scenarios

References

- Sturgis, P., Brunton-Smith, I., & Jackson, J. (2021). Trust in science, social consensus and vaccine confidence. Nature Human Behaviour, 5(11), 1528-1534.
- Viskupič, F., Wiltse, D. L., & Meyer, B. A. (2022). Trust in physicians and trust in government predict COVID‐19 vaccine uptake. Social Science Quarterly, 103(3), 509-520.
- Kaufman, J., Overmars, I., Leask, J., Seale, H., Chisholm, M., Hart, J., ... & Danchin, M. (2022). Vaccine Champions Training Program: Empowering Community Leaders to Advocate for COVID-19 Vaccines. Vaccines, 10(11), 1893.
- World Health Organization. (2022). Behavioural and social drivers of vaccination: tools and practical guidance for achieving high uptake. World Health Organization. https://apps.who.int/iris/handle/10665/354459.

THANK YOU

Special thanks to Michael Maes for guiding our project development