Multi-agent simulation of trust in vaccination

Project presentation

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Internship financed by CNRS MODCOV19
Supervised by Carole Adam (LIG) and Didier Georges (GIPSA-lab)

Masters defence - 4 July 2022

SARS-CoV-2 and COVID-19

- Emergence in late December 2019

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- Urgent approval of vaccines using new techniques
- Misinformation and disinformation

Problem

Misinformation and disinformation

- Lower trust in vaccines and institutions
- Lower vaccination rates

Goal

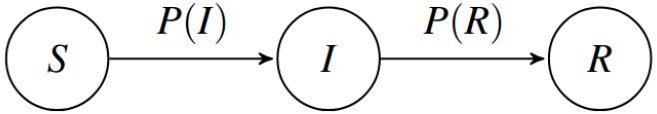
Educational simulation

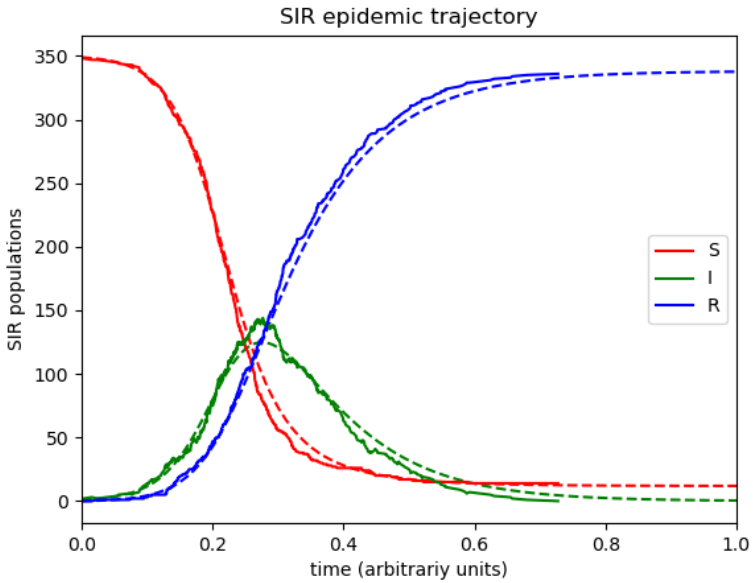
- Agent-based simulations on vaccine effectiveness
- Public trust in vaccines

In the continuity of CoVprehension

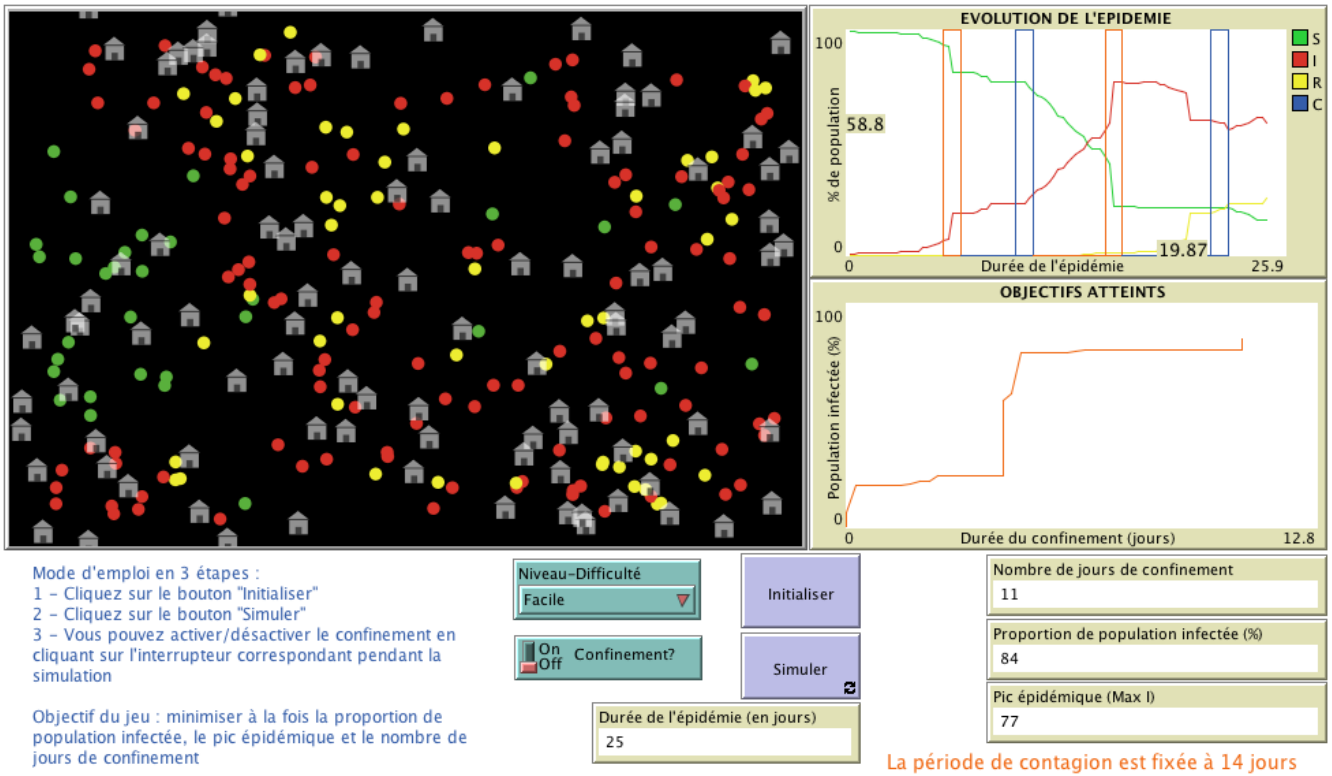
With the help of Pierrick Tranouez
(Litis, University of Rouen Normandie)

Epidemic simulations - Mathematical models





Epidemic simulations - Agent-based models (ABM)



https://covprehension.org/2020/03/30/q6.html

Epidemic simulations

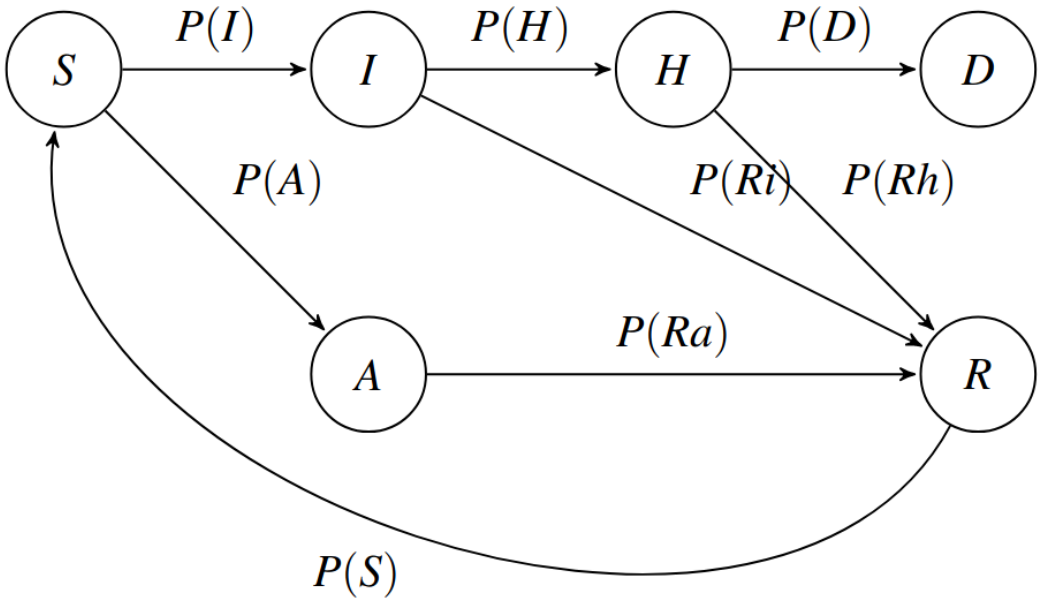
Mathematical models

- Homogeneous
- Macro-level model & analysis

Agent-based models

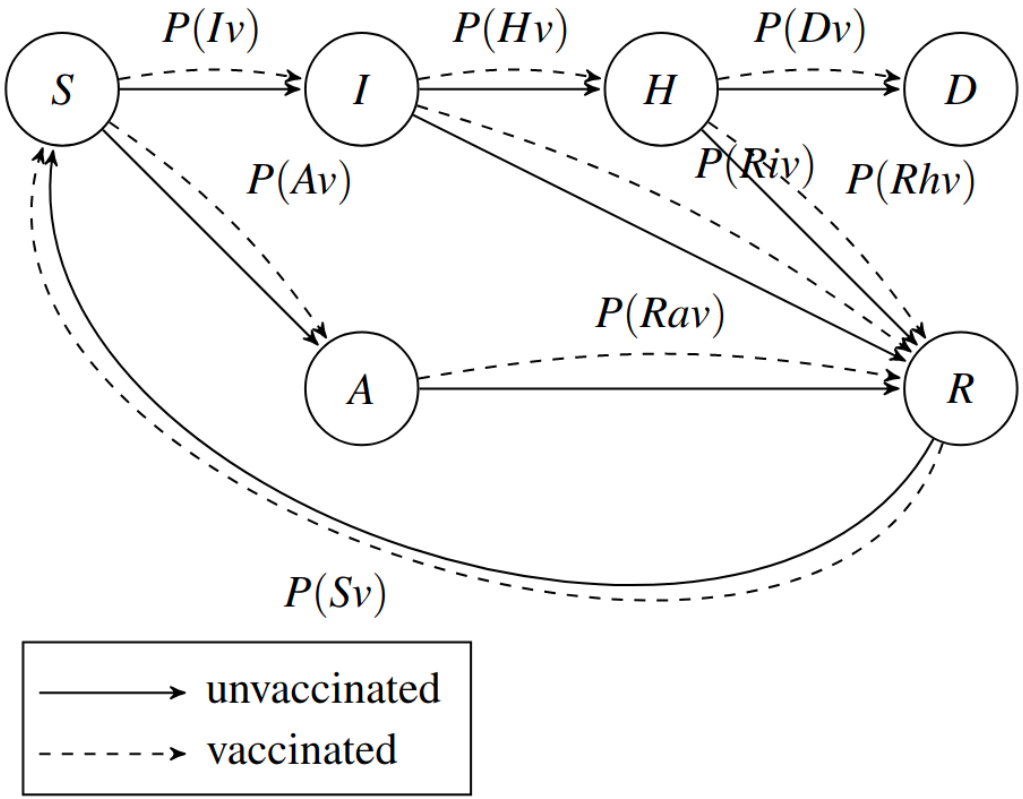
- Heterogeneous
- Micro-level model
- Macro-level analysis

Compartmental model



S: Susceptible; I: Symptomatic; A: Asymptomatic; H: Hospitalised; R: Recovered; D: Deceased

Compartmental model with vaccination



S: Susceptible; I: Symptomatic; A: Asymptomatic; H: Hospitalised; R: Recovered; D: Deceased

Compartmental model probabilities

x : *virus dangerousness*

$$P(T) = 1/2 * x$$
$$P(I) = 1 - P(A)$$
$$P(A) = P(T) + 1/4 * (1 - x)$$
$$P(H) = 7/10 * x + i$$
$$P(D) = 1/2 * x + h$$
$$P(Ri) = 1 - P(H)$$
$$P(Rh) = 1 - P(D)$$
$$P(Ra) = a$$
$$P(S) = 1/2 * x + r$$

y : *vaccine effectiveness*

$$P(Tv) = P(T) * (1 - y)$$
$$P(Iv) = 1 - P(Av)$$
$$P(Av) = P(A) * y$$
$$P(Hv) = P(H) * (1 - y)$$
$$P(Dv) = P(D) * (1 - y)$$
$$P(Riv) = P(Ri)$$
$$P(Rhv) = P(Rh)$$
$$P(Rav) = P(Ra)$$
$$P(Sv) = P(S) * (1 - y)$$

$, i \sim \mathcal{N}(2.1, 0.1), h \sim \mathcal{N}(1.0, 0.3), a \sim \mathcal{N}(1.5, 0.2), r \sim \mathcal{N}(6, 3)$

Agents

Attributes

- Epidemiological state (S, I, A, H, R, D)
- Vaccine status (boolean)
- Trust level (float: 0.0 - 1.0)

Behaviour

- Move randomly
- Influence each other's trust
- Symptomatic & Asymptomatic infect Susceptibles only
- Hospitalised are put apart
- Susceptible, Asymptomatic & Recovered visit hospitalised
- Uninfected vaccinate themselves based on their trust level and available doses

Trust and agent interactions (1/3)

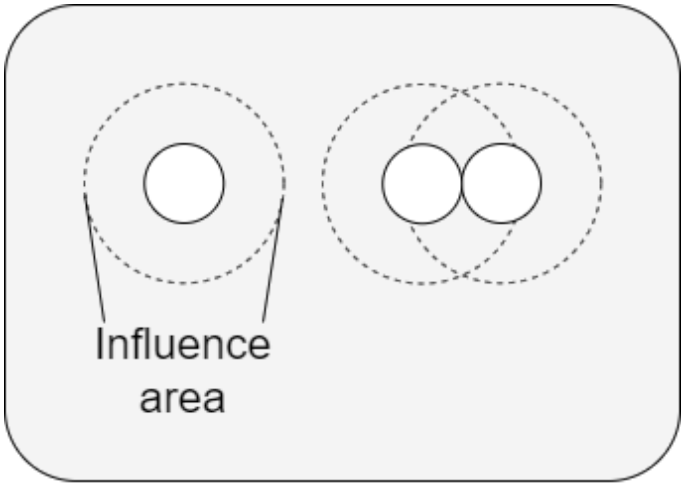


Figure 1: Interpersonal influence

Trust and agent interactions (2/3)

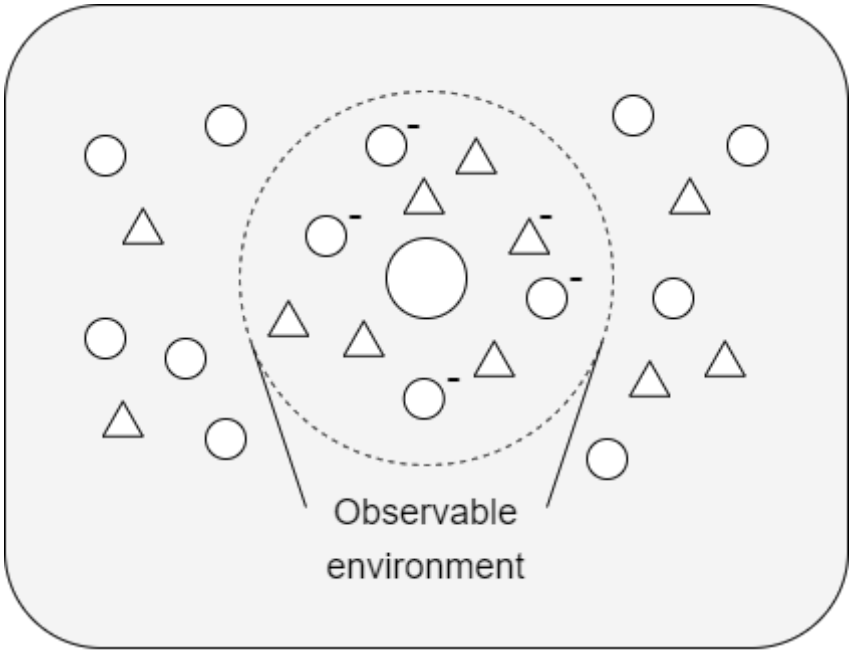


Figure 2: Observational influence

Trust and agent interactions (3/3)

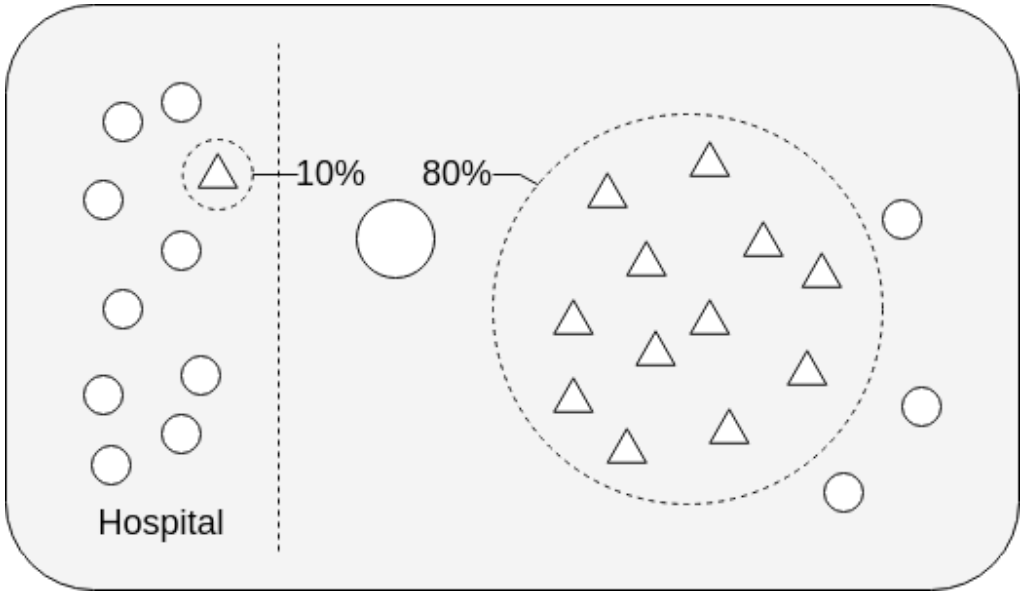
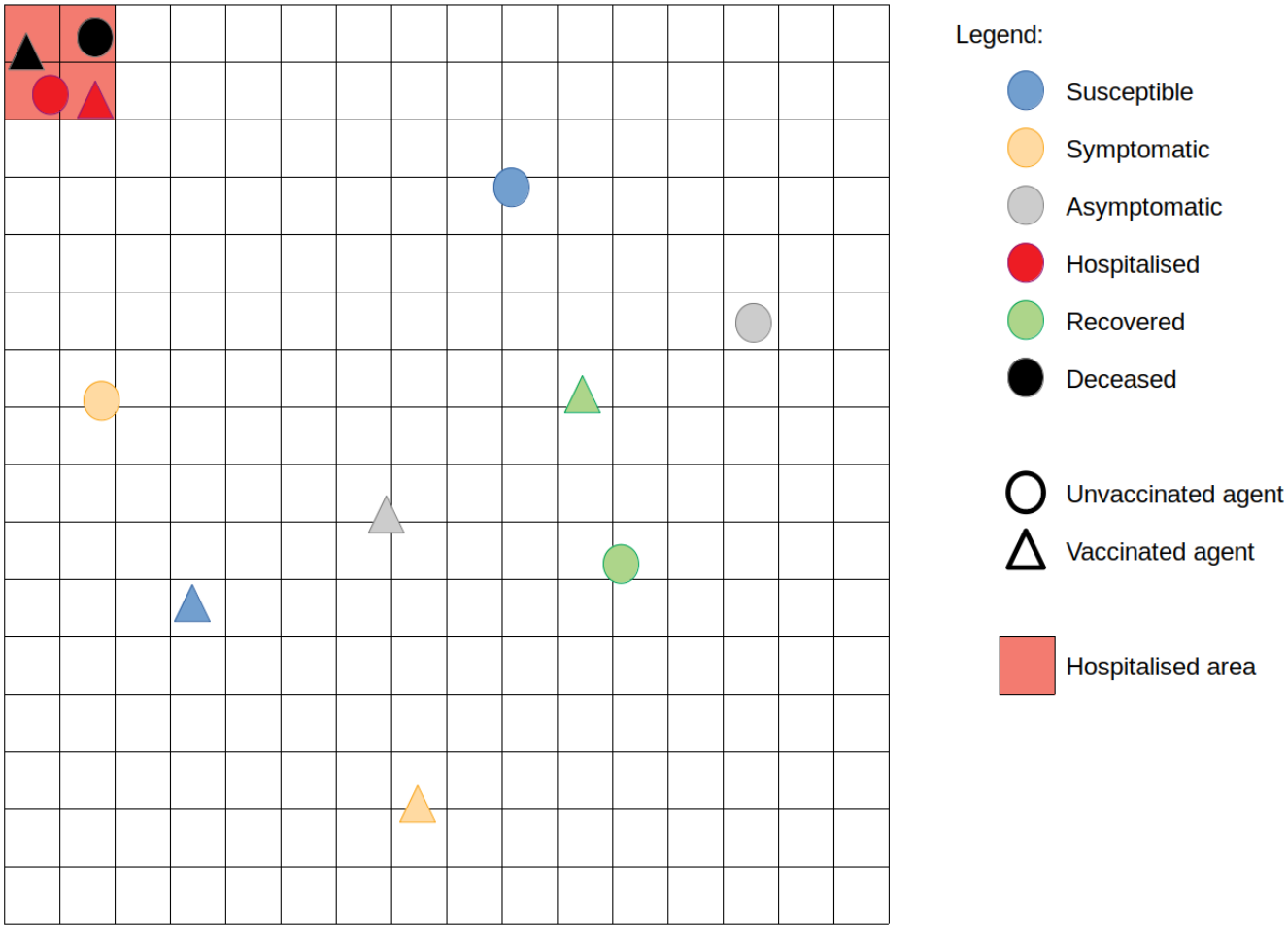


Figure 3: Institutional influence and misinterpretation

Details

- NetLogo
- ~800 lines
- Based on CoVprehension's Q17
- Available on GitHub & CoVprehension

Simulation environment



Environment details

- 2000 agents
- Agents initialised unvaccinated
- Agents initialised in the Susceptible class
- One agent initialised in the Symptomatic class
- Trust initialised randomly following custom law

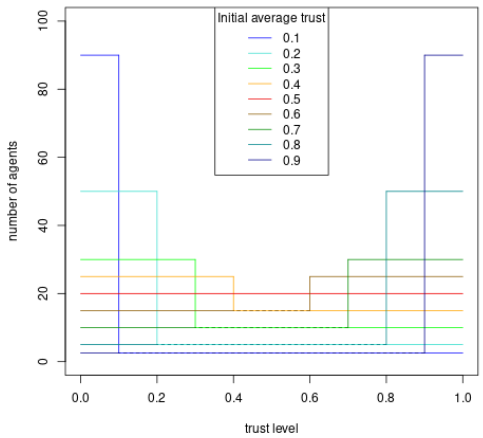


Figure 4: Output of the algorithm used in the initialisation of the population's average trust.

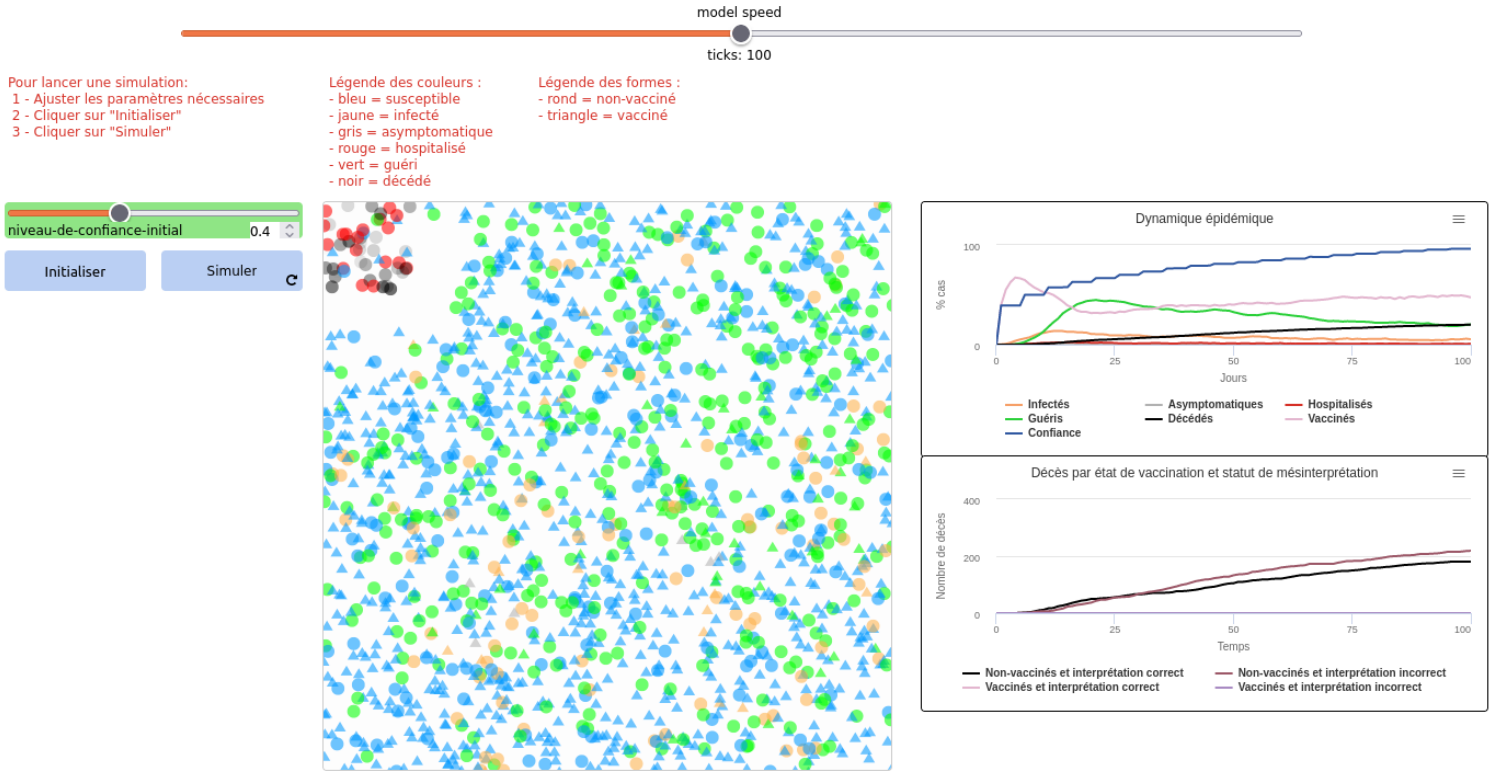
Inputs & Outputs

Input:

- Population average initial trust (0.1 - 0.9)

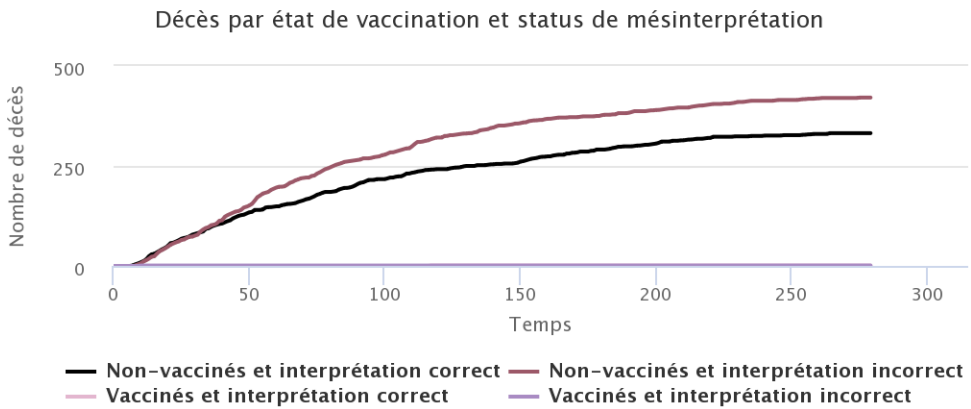
Output:

- Deceased per vaccination & per misinterpretation status



Misinterpretation of information

Population's initial average trust: **0.3**



Population's initial average trust: **0.7**

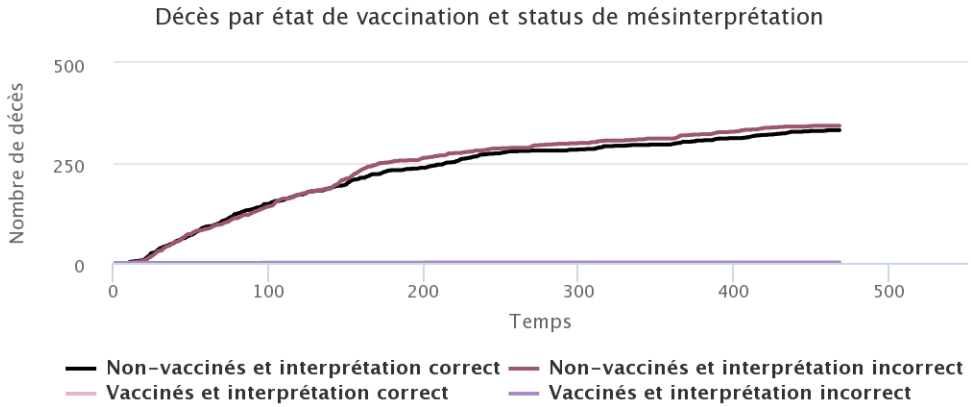


Figure 5: Deceased per vaccination & per misinterpretation status

Contribution

- Combination of epidemiological ABM & trust in vaccines
- Population trust is important and needed before the start of the vaccination campaign
- Making sure that the population correctly understands given information is crucial to heighten trust and give people the desire to get vaccinated

Future plans

- Add age groups
- Households (influence trust among families)
- Distrust when insufficient available vaccines
- Different types of information sources (influence trust differently)

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