Game Theory and Vaccination

Seminar: Epidemics, Infodemics and Mobility

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Group 1

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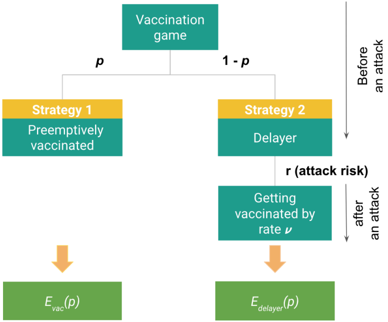
Vaccination Game

Group interest versus self-interest in smallpox vaccination policy

Chris T. Bauch and Alison P. Galvani and David J. D. Earn , 2003



Group interest versus self-interest in smallpox vaccination policy

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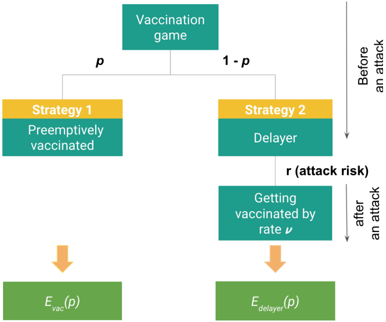


- Individual Equilibrium ($p = p_{ind}$):

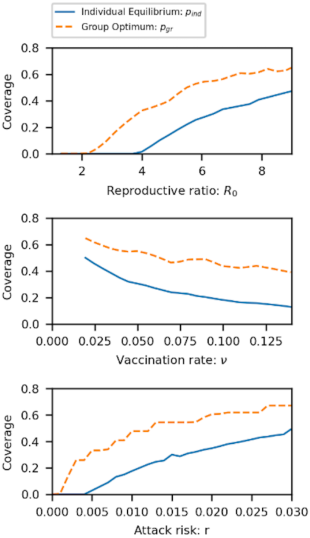
  $E_{vac}(p_{ind}) = E_{delayer}(p_{ind})$

- Group optimum ($p = p_{gr}$):

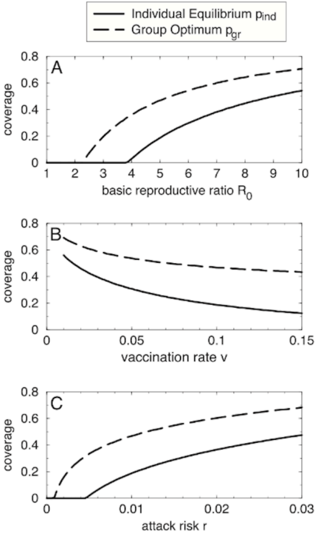
  $C(p) = -pE_{vac}(p) - (1-p)E_{delayer}(p)$

  $\frac{dC(p)}{dp}|_{p=p_{gr}} = 0$

Recreation the paper's plots



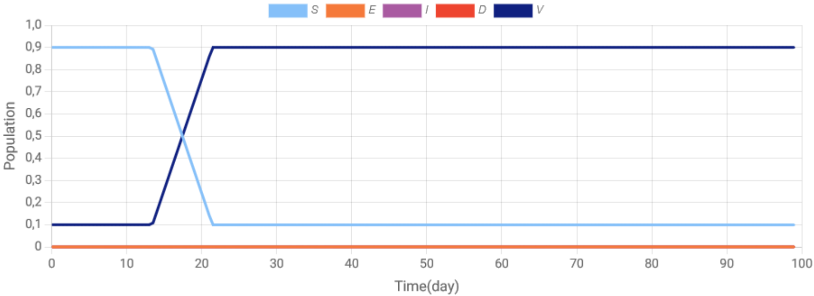
a) Our results



b) Paper's results

The SEIDV Model

- S: susceptible
- E: infected but not yet infectious
- I: infectious
- D: removed (dead/immune) due to smallpox
- V: removed (dead/immune) due to vaccination



Website with SEIDV model

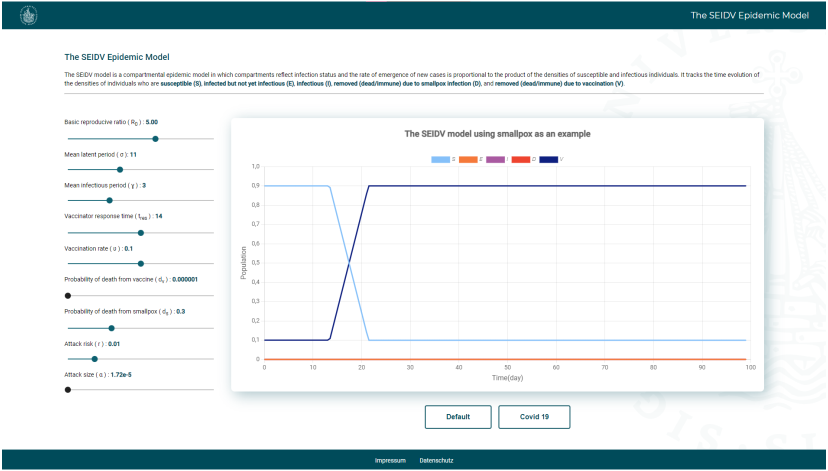


Figure: Link to the website: `https://seidv-model.web.app`

Payoff Functions for Corona Vaccination

Strategy for Vaccination:
$E_{vac} = -d_v$

Strategy for no Vaccination:
$E_{unvac} = -d_{cov} \cdot \frac{(I(T_2, age) - I(T_1, age))}{N(age)}$

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- **How does age affect vaccination decision?**
- Risk of death for Corona is age dependent
  $d_{cov} = d_{cov}(age)$
- Infection fatality rate ($d_{cov}(age)$= IFR)

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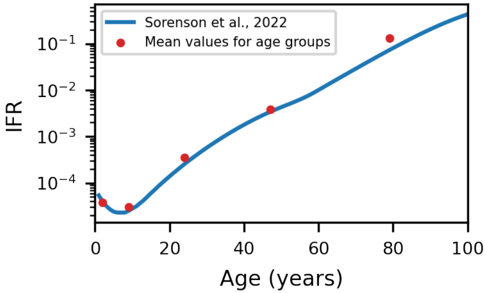

Figure: Infection fatality rate for different ages groups from [**Sorensen**, **Reed JD et al.**, **2022**] and calculated mean for age groups

Calculating critical age for covid vaccination

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- Age groups:
  - 0-4
  - 5-14
  - 15-34
  - 35-59
  - $\geq$60
- critical age: $E_{vac} = E_{unvac}$

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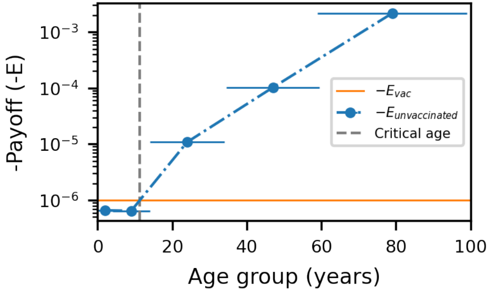
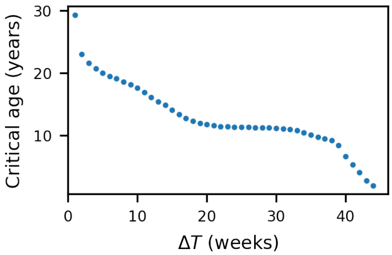


Figure: finding critical age for Covid19 vaccination from T_1 = January 2021 to T_2 = July 2021

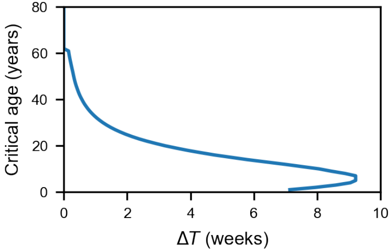
Result: Critical age depends on time period of planning

Critical age:

Probability of dying from vaccination = probability of dying due to Covid-19 during period of time ΔT



(a) Real data[1]



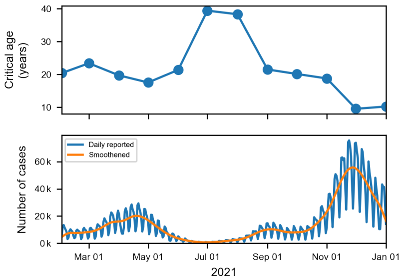
(b) SEIDV prediction

Figure: Critical age $E_{vac} = E_{unvac}$ for Covid19 vaccination as a function of time period of planning, simulated on (a) real data (b) data from the SEIDV prediction with Covid19 data[2] for T_1

[1] **Population size: [Statista Research Department**, **21.06.2022]** , **Covid19: [Kaggle**, **01.07.2022]** .

Result: Critical age over the course of the pandemic

Fixed the time period $\Delta T = 1$ month



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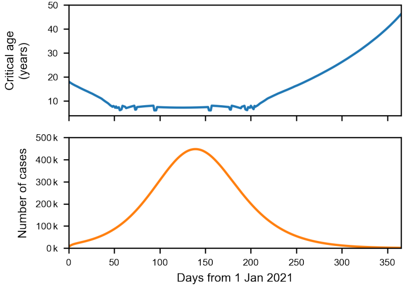

(b) SEIDV prediction

Figure: Critical age for decision time period $\Delta T = 1$ month over one year (2021) of the pendemic, simulated on (a) real data (b) data from the SEIDV prediction Covid19 data[3] for T_1

[3] **[Our World in Data, 2020]**.

Conclusion and Outlook

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- Time period of decision decreases for the elderly people. They needs to get vaccination as soon as possible.
- Low infectious rate extends the range of age not to get vaccination within the fixed period of time.

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- Not all people can decide rationally.
- SEIDV is not good enough for real pandemic.
- Assumption on vaccination efficiency

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Outlook

- Feedback loop: decision based on game theory also affects the vaccination rate

References

Chris T. Bauch and Alison P. Galvani and David J. D. Earn (2003)
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