Aalto-yliopisto
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Analyzing effects of vaccination strategies on the COVID-19 pandemic
(topic presentation)

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Background

- COVID-19 pandemic has a huge effect on the world.
- Vaccines are being developed (Archana et al. 2020)
- How to use them efficiently?

Goals

- Develop a model which helps to understand how to prioritize vaccination against infectious diseases
- Same model should work for other infectious diseases
- How big are differences of alternative vaccination strategies. Are they big enough to matter?
- Understand the limits of simple modelling (Lahtinen et al. 2017)

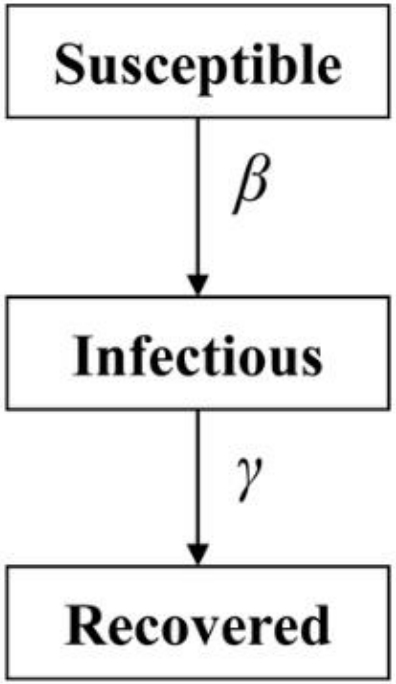
Vaccination Strategy

- Vaccination strategy = Prioritization of vaccination among population segments or timing of vaccination
- Examples of vaccination strategies for various diseases
  - Pulse vaccination vs constant vaccination
  - Vaccinating different age or risk groups
  - Vaccination in response to outbreak vs pre-epidemic
- Vaccination strategies of vaccine-preventable diseases are helpful
- Examples: MMR, rotavirus, Hepatitis A and B

Methods

- General SIR-model (S = Susceptible, I = Infected, R = Recovered)
- Start with a simple model and examine how a disease behaves without vaccination
- Add a group V (vaccinated)
- Implemented in MATLAB
- Starting parameters estimated from gathered data
- Why SIR-model?
  - Simple and widely used (Hardt et al. 2016, Biswas et al. 2014, Nguyen & Carlson 2016)
  - Easy to extend (SEIR, SERIS, SIRD, MSEIRS etc.)

Methods: Basic SIR-model



$$\frac{dS}{dt} = -\beta SI$$

$$\frac{dI}{dt} = \beta SI - \gamma I$$

$$\frac{dR}{dt} = \gamma I$$

Luz et al. 2010

Methods: Extended SIR-model

- Divide groups S,I,R and V based on age
- Objective is to minimize the total amount of infections
- How the total amount of infections depends on vaccination strategy?

Schedule

- 10/2020 Presenting the topic
- First half of 11/2020: Finish modelling
- Second half of 11/2020: Writing
- 12/2020: Presenting the results
- Finish before winter break

References

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- Nguyen, C., & Carlson, J. M. (2016). **Optimizing Real-Time Vaccine Allocation in a Stochastic SIR Model**. *PloS one*, *11*(4), e0152950. https://doi.org/10.1371/journal.pone.0152950
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- Lahtinen, Tuomas & Guillaume, Joseph & Hämäläinen, Raimo. (2017). **Why pay attention to paths in the practice of environmental modelling?.** *Environmental Modelling and Software*. 92. 74-81. 10.1016/j.envsoft.2017.02.019.