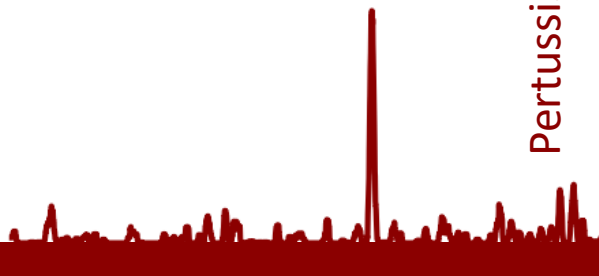
Pertussis resurgence in societies with high vaccination coverage

Hannah Niese, Markus Niese, Timo Schönegg



Recent cases

HEALTH > Posted November 19 | Updated November 20

New whooping cough cases jumped in October, to highest monthly total of 2018

York County continues to be a hot spot for
disease, and low vaccination rates are thou

BY JOE LAWLOR STAFF WRITER

Health experts cite three major reasons why Maine
infections: parents opting their children out of sch
waning effectiveness of the vaccine, which require
being late to adopt a required booster shot for mid
state didn't establish the requirement until the 20

No, immigrants are not behind pertussis resurgence

By Susan Perry | 02/18/2015

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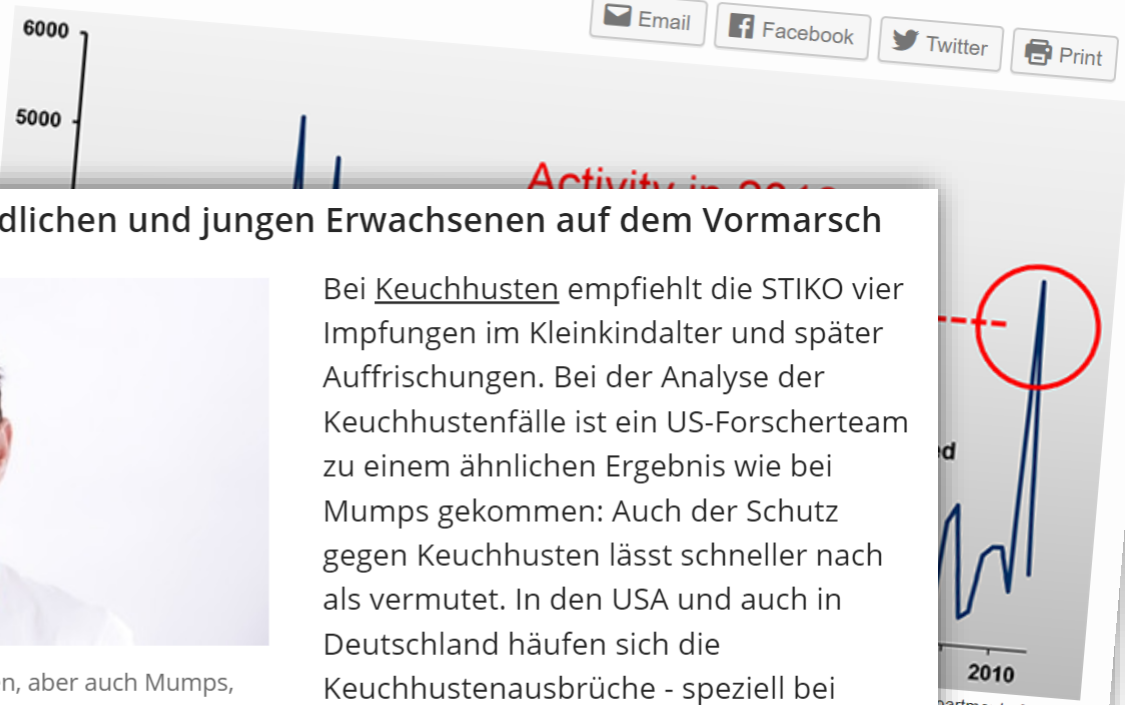


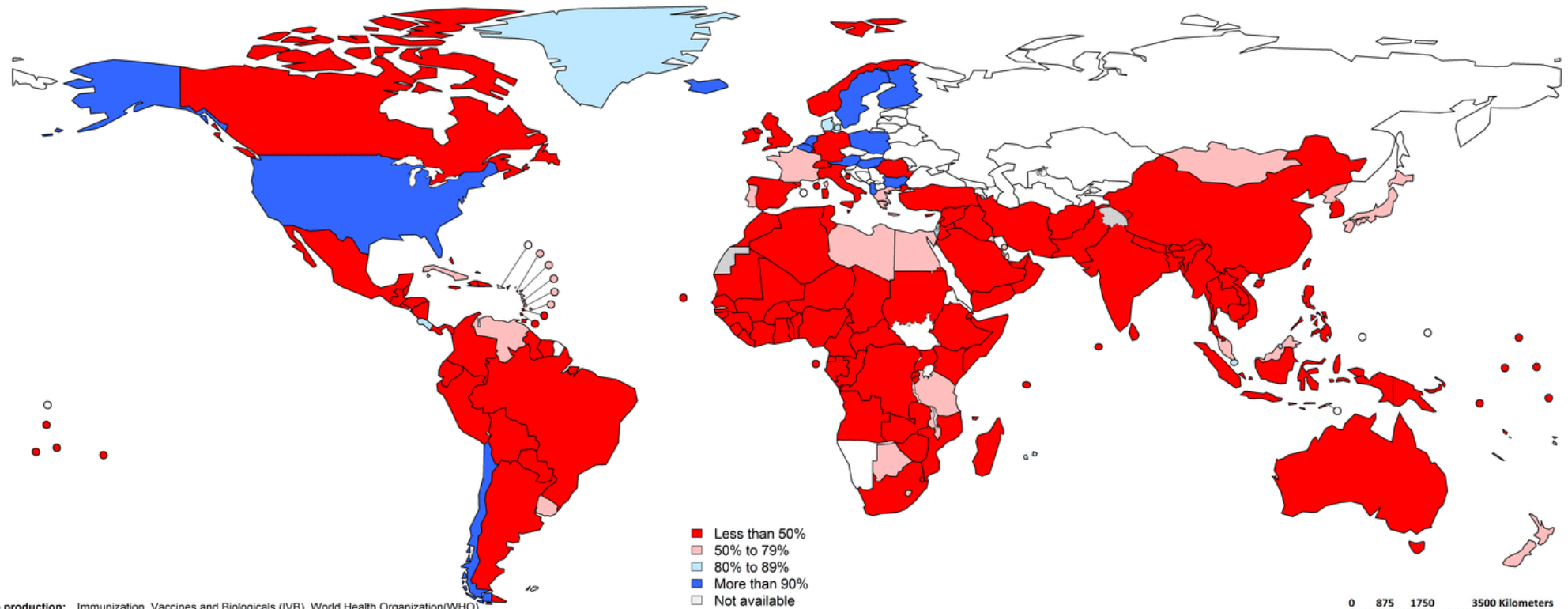
Keuchhusten bei Jugendlichen und jungen Erwachsenen auf dem Vormarsch

Kinderkrankheiten wie Keuchhusten, aber auch Mumps, nehmen zu, weil sich Jugendliche zu wenig impfen lassen. Keuchhusten ist ansteckend.

Bei Keuchhusten empfiehlt die STIKO vier Impfungen im Kleinkindalter und später Auffrischungen. Bei der Analyse der Keuchhustenfälle ist ein US-Forscherteam zu einem ähnlichen Ergebnis wie bei Mumps gekommen: Auch der Schutz gegen Keuchhusten lässt schneller nach als vermutet. In den USA und auch in Deutschland häufen sich die Keuchhustenausbrüche - speziell bei Jugendlichen und Erwachsenen, die nur in der Kindheit geimpft wurden.

Immunization coverage with 3rd dose of diphteria and tetanus toxoid and pertussis containing vaccines

1980



Map production: Immunization, Vaccines and Biologicals (IVB), World Health Organization(WHO)
Data source: WHO/UNICEF estimates 2016 revision, March 2018.
194 WHO Member states.

Disclaimer:

The boundaries and names shown and the designations used on this map do notimply the expression of any opinion whatsoever on the part of the World Health Organization concerning the legal status of any country, territory, city or area nor of its authorities, or concerning the delimitation of its frontiers or boundaries. Dotted and dashed lines on maps represent approximate border lines for which there may not yet be full agreement.

World Health Organization

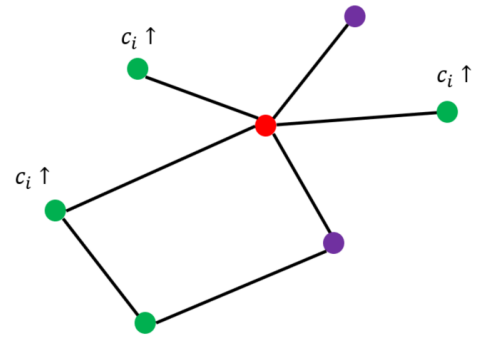
SIR Model

Pertussis
- Human-to-human infection
- Incubation (7-14 days)
- Duration (6 weeks)
- Probability of infection 0.5

Immunity
- 100% protection
- Waning immunity:
  12 years (std. dev. 2 years)

Vaccination Decision

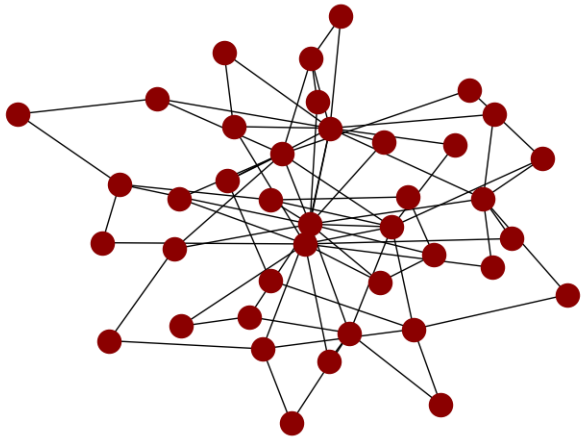
Cost function
- Perceived cost of vaccination
- Perceived cost of infection



$$E = -c_v + c_i \cdot L_i \cdot (1 - L_c) \cdot p$$

Network

Barabási-Albert Network



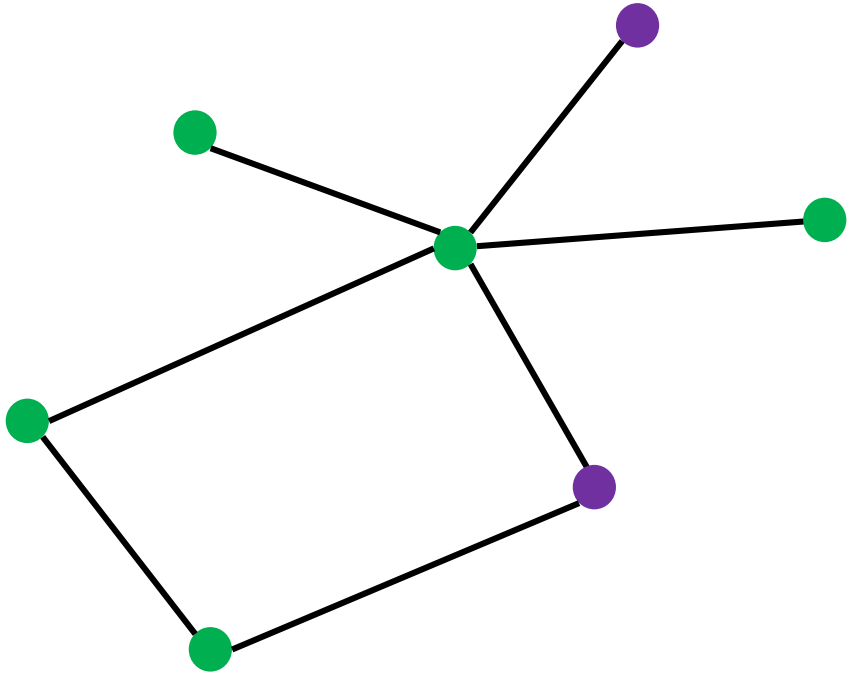
Results:
- Coverage level
- Effects of waning immunity

⇒ consistent with medical records

Could be used for:
- Policy Analysis
- Design vaccination programmes

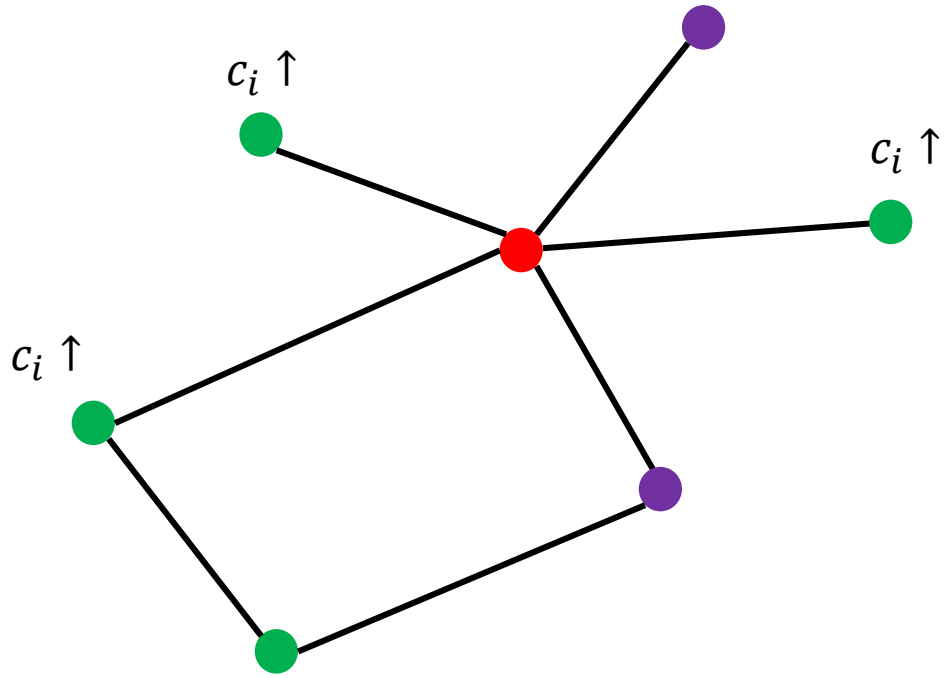
⇒ better specification needed

Infection



Healthy
Recently infected
Vaccinated

Infection



- Healthy
- Recently infected
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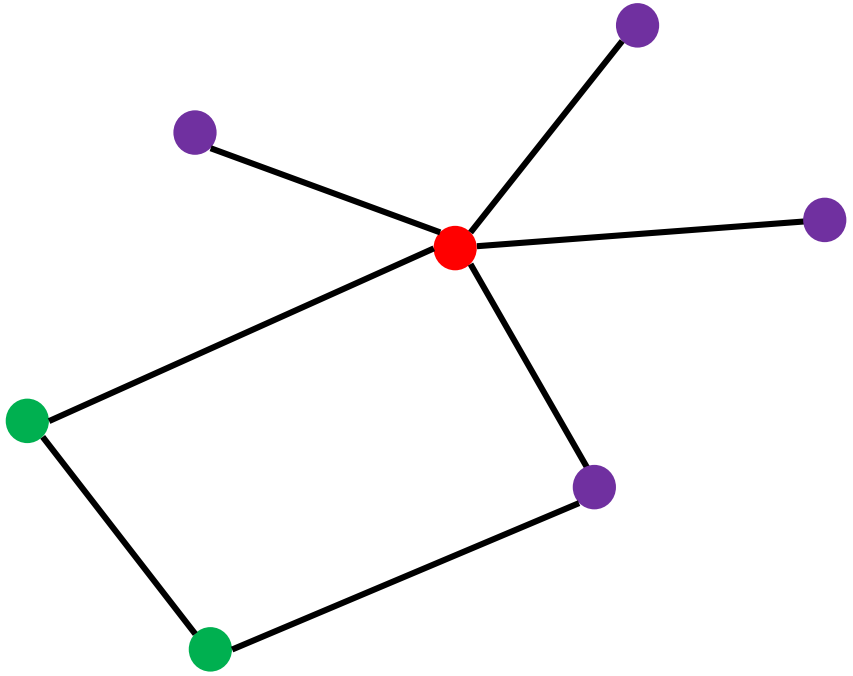
Infection



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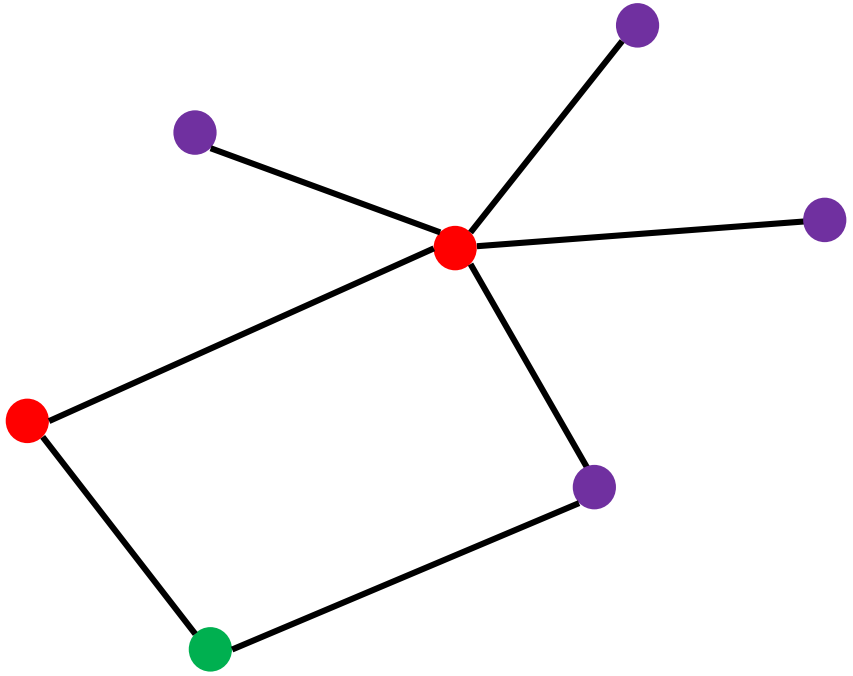
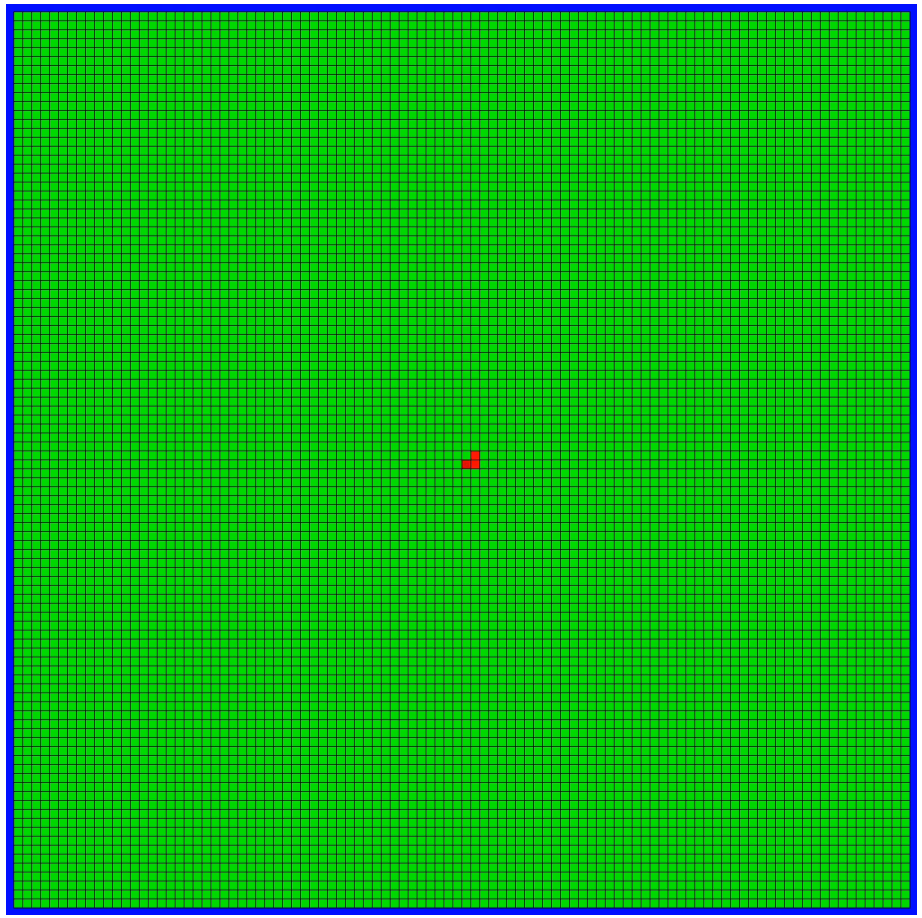


$c_i \uparrow$

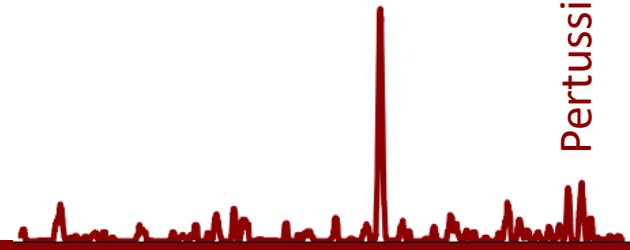
- Healthy
- Recently infected
- Vaccinated

Visualisation on a Grid



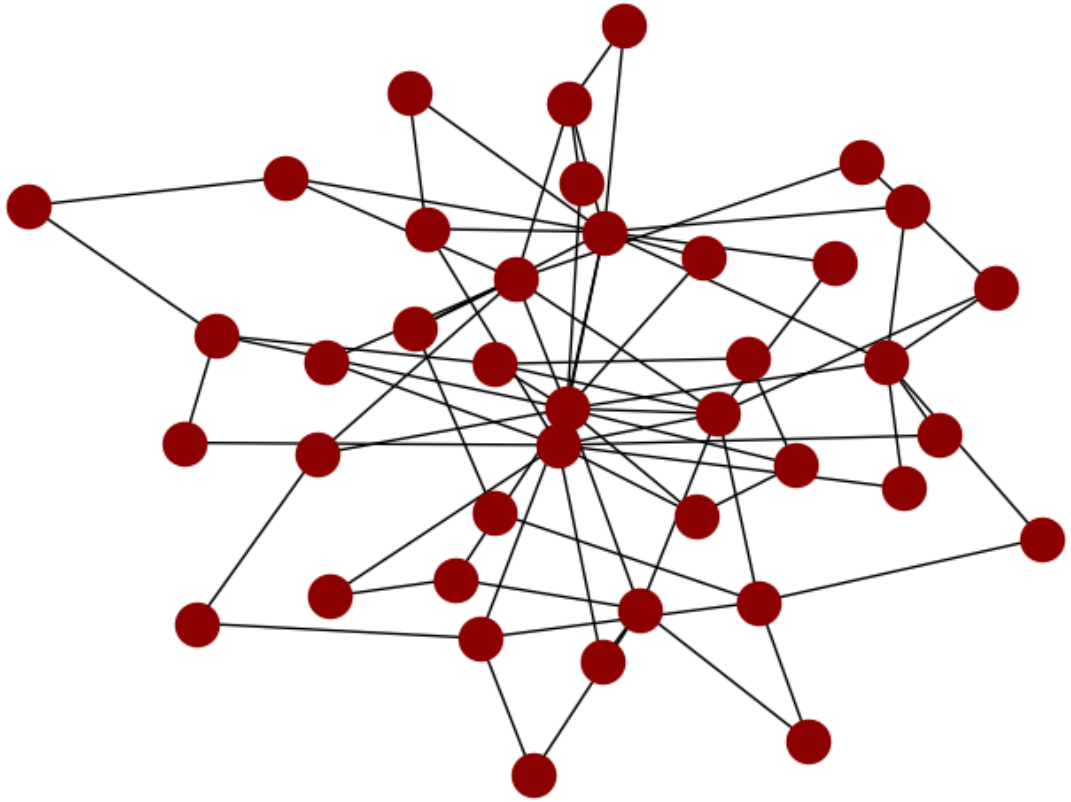
Population: 10,000

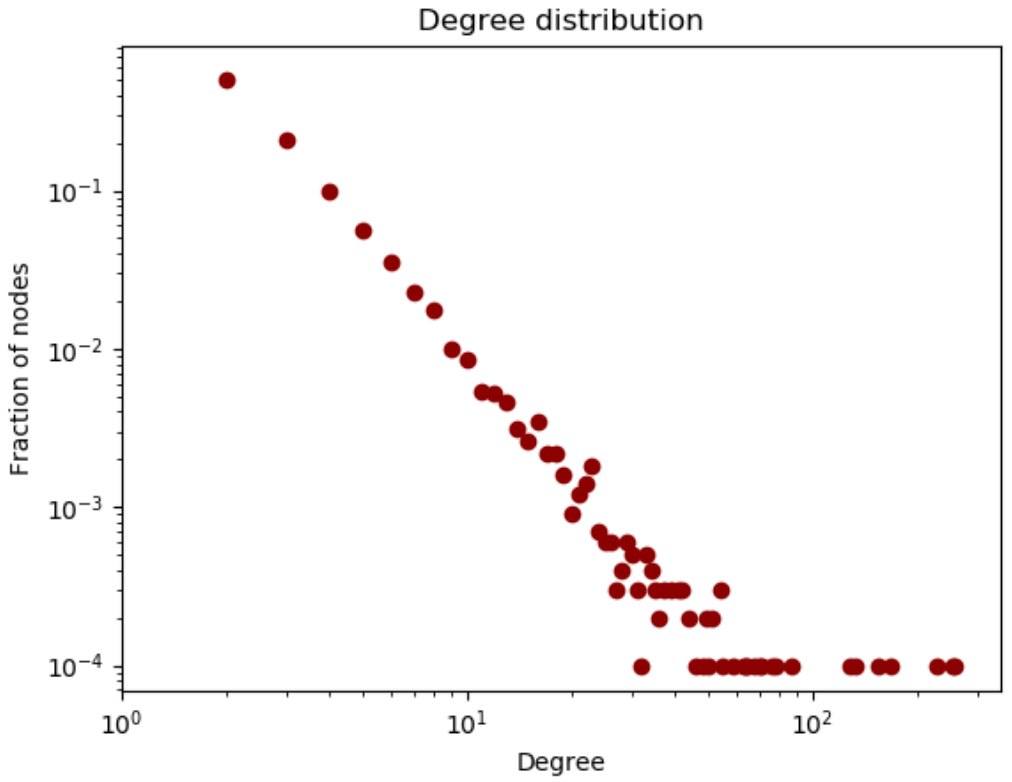
- Healthy
- Recently infected
- Infected, but not contagious
- Immune
- Vaccinated



Network structure

10,000 nodes



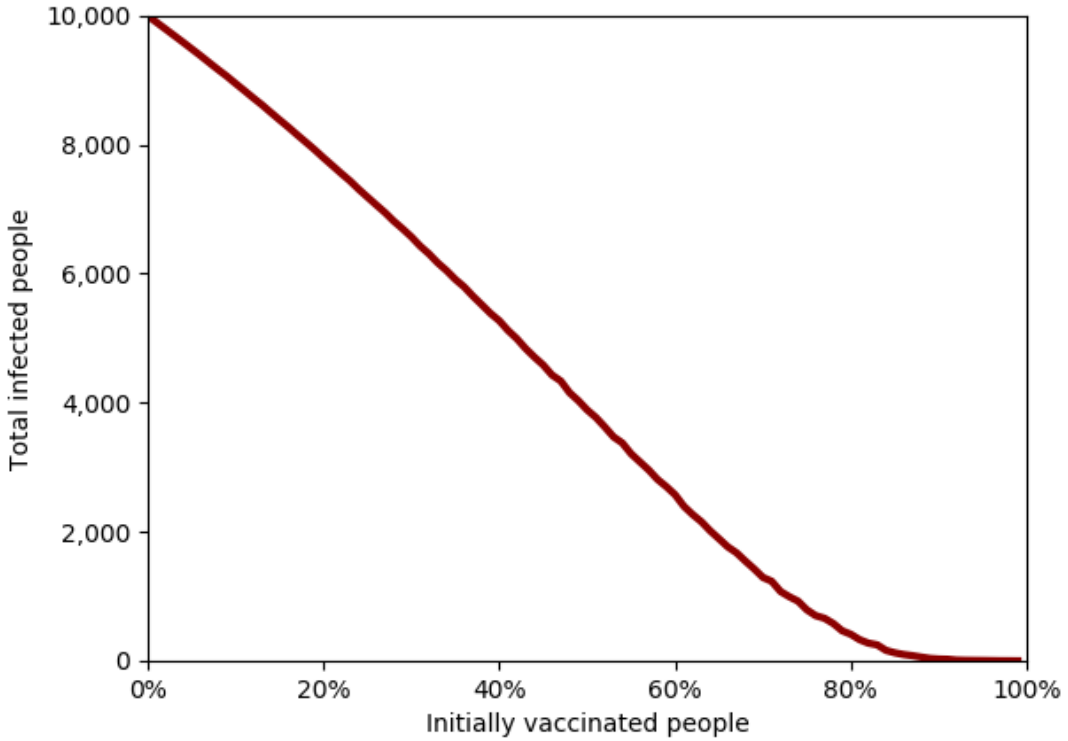


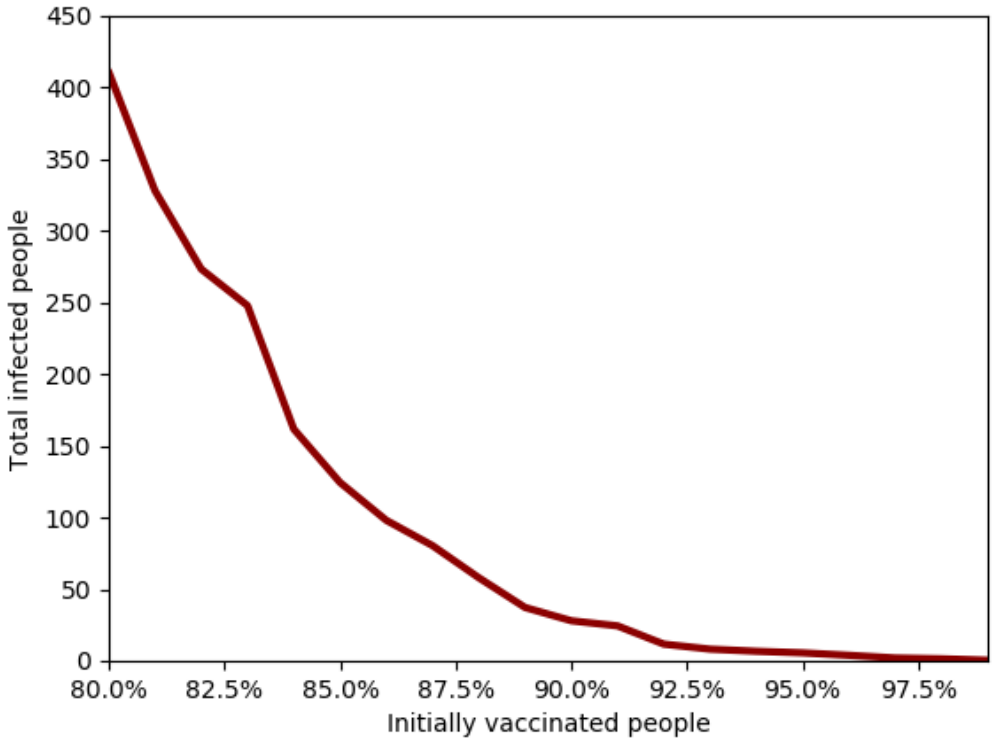
Pertussis resurgence

Short term analysis

Determining vaccination coverage rates

Population: 10,000
Number of people who were infected during the first 500 days of the outbreak





Cost function and initial conditions

$$E = -c_v + c_i \cdot L_i \cdot (1 - L_c) \cdot p$$

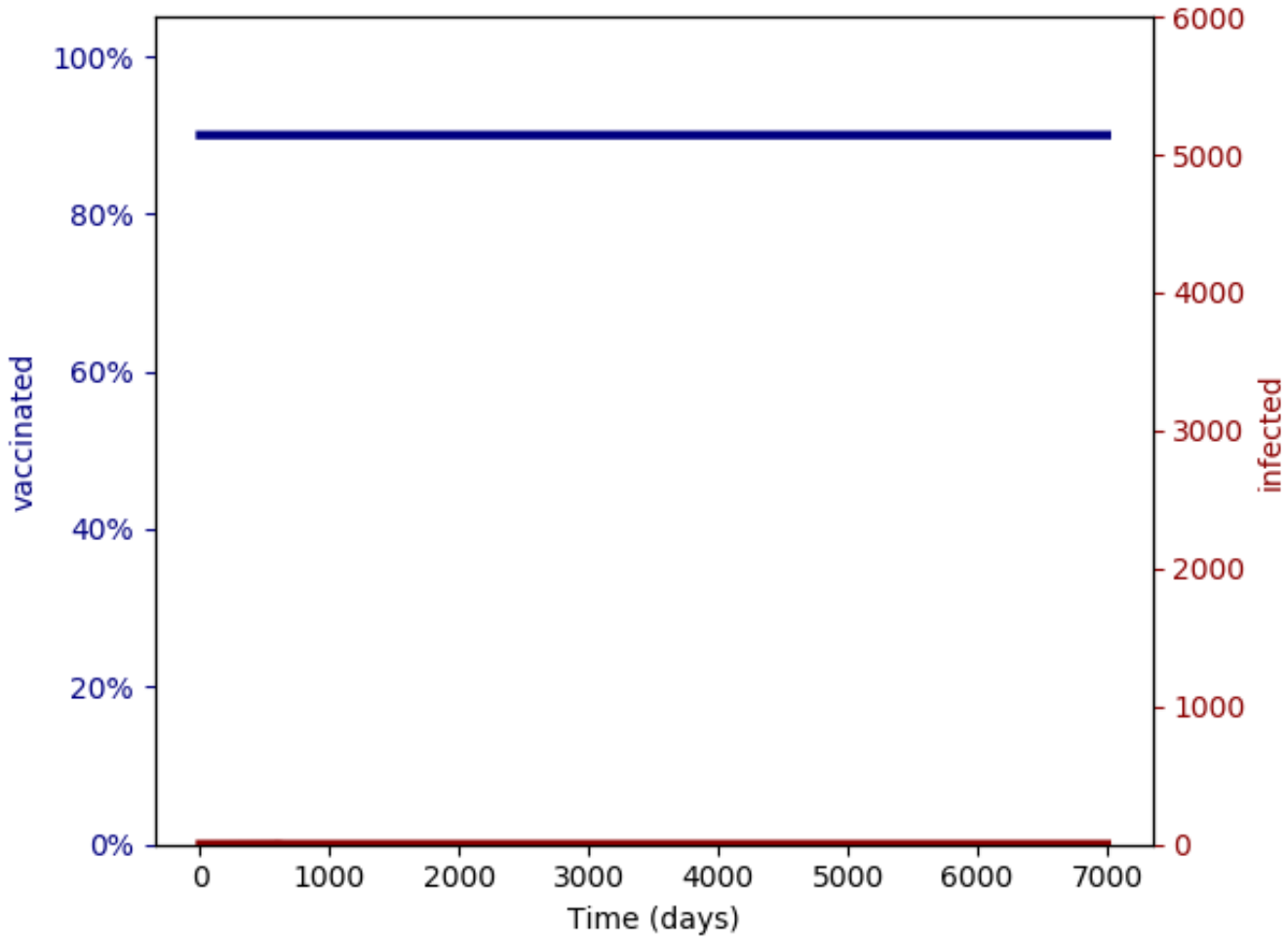
E	expected_gain
c_v	percieved cost due to vaccination
c_i	percieved cost due to infection
L_i	infection level
L_c	coverage level
p	risk of getting infected when there is contact

$E > 0$: vaccinate

$E < 0$: do not vaccinate

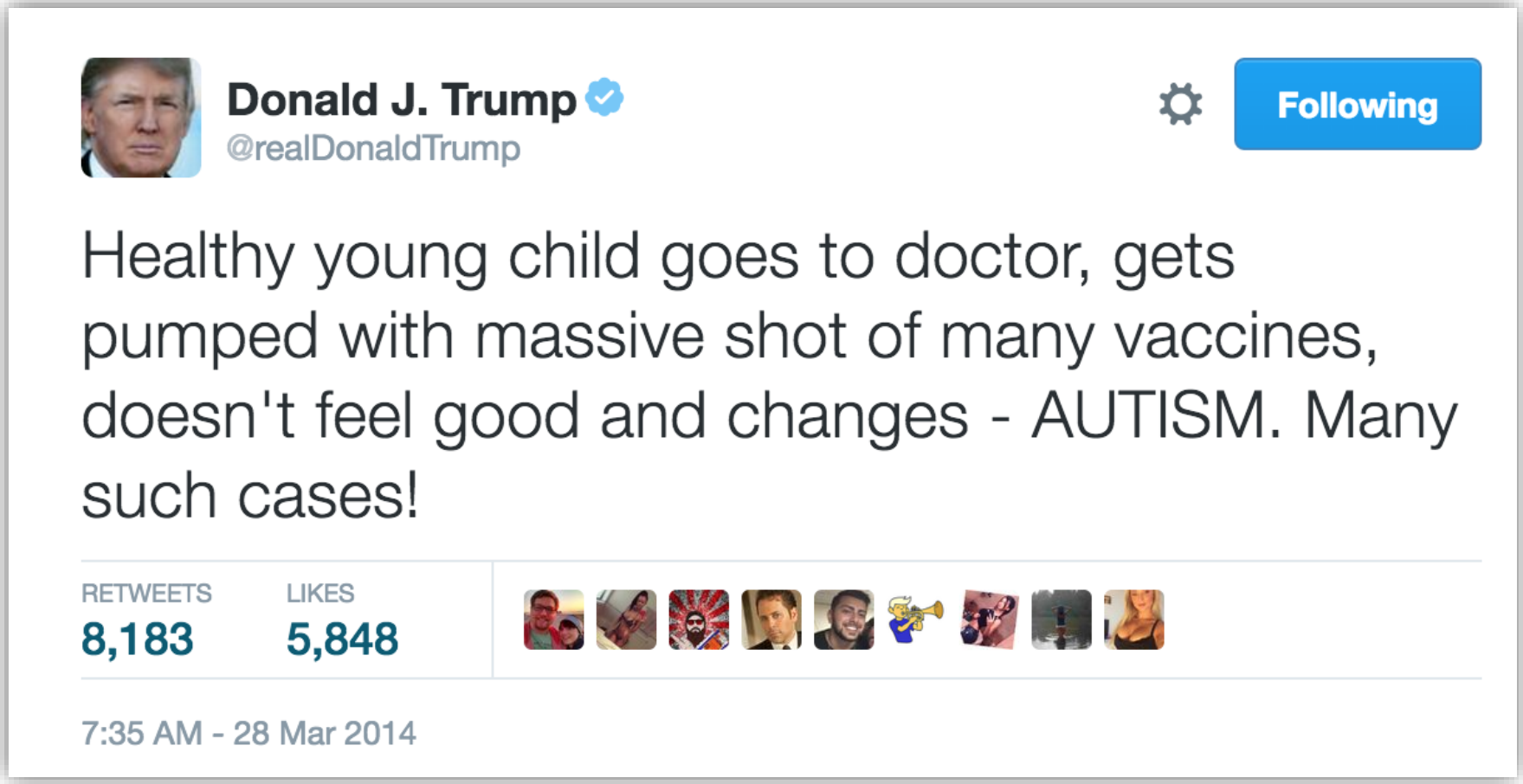
Bauch & Earn (2004). Vaccination and the theory of games

Vaccination scares



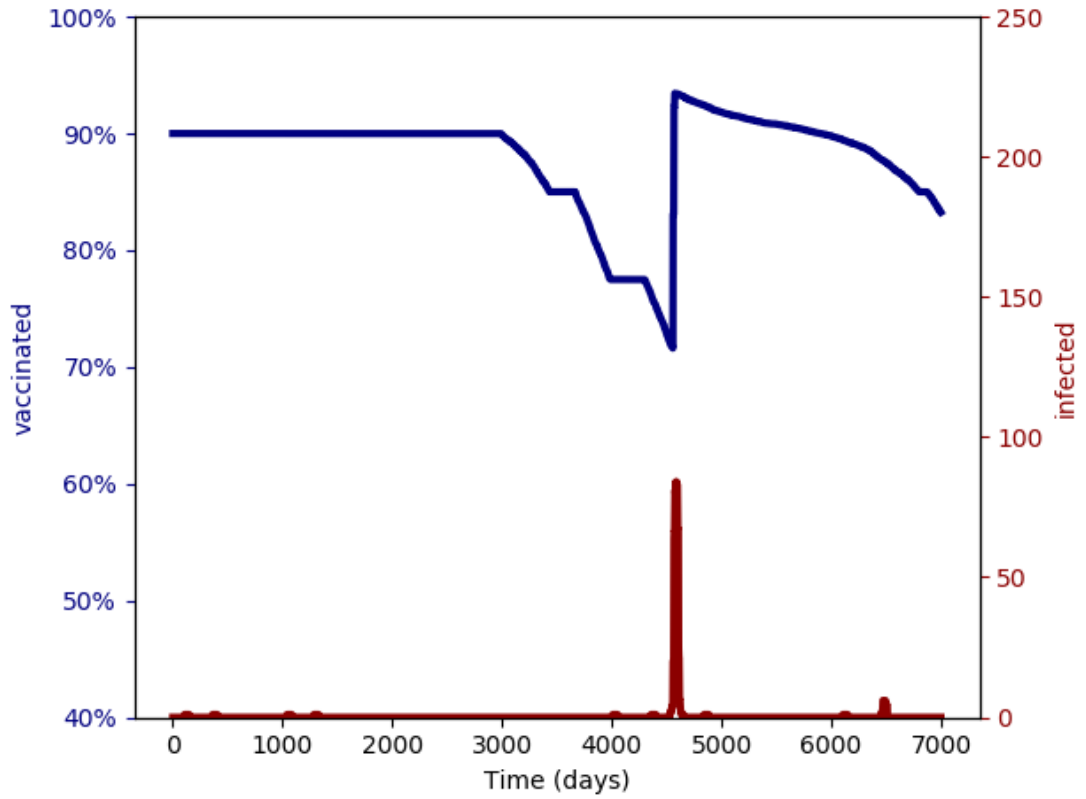
Pertussis resurgence

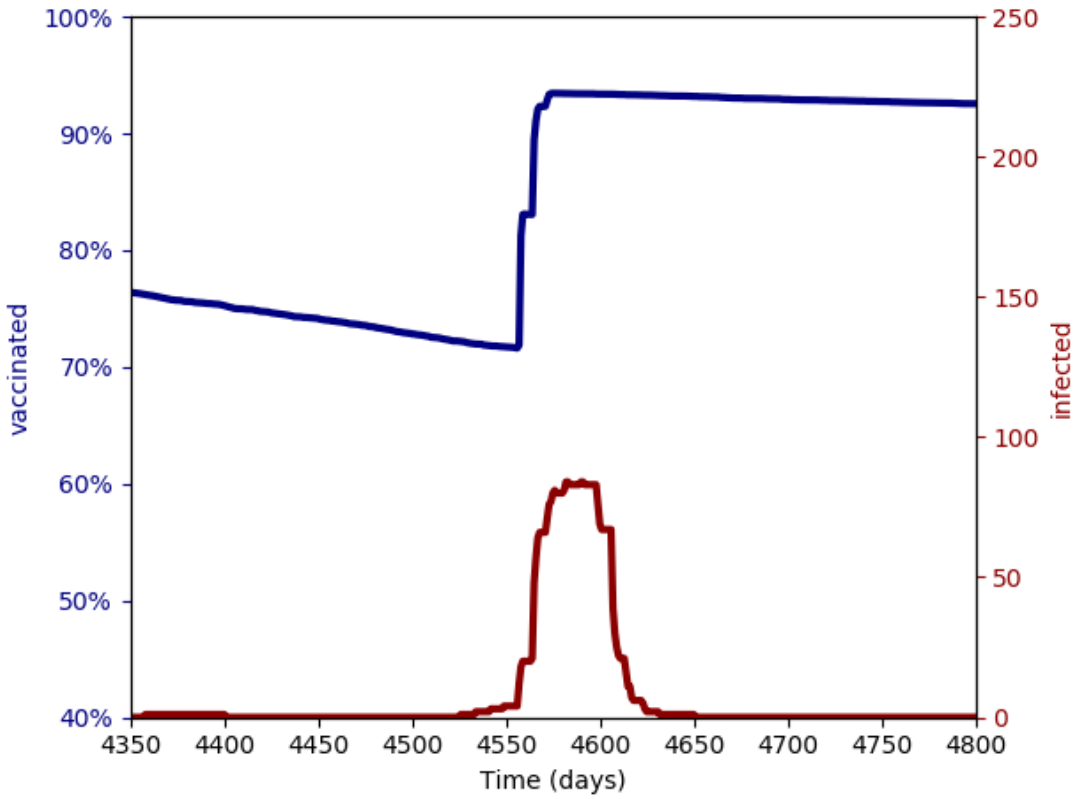
Vaccination scares



Long term analysis

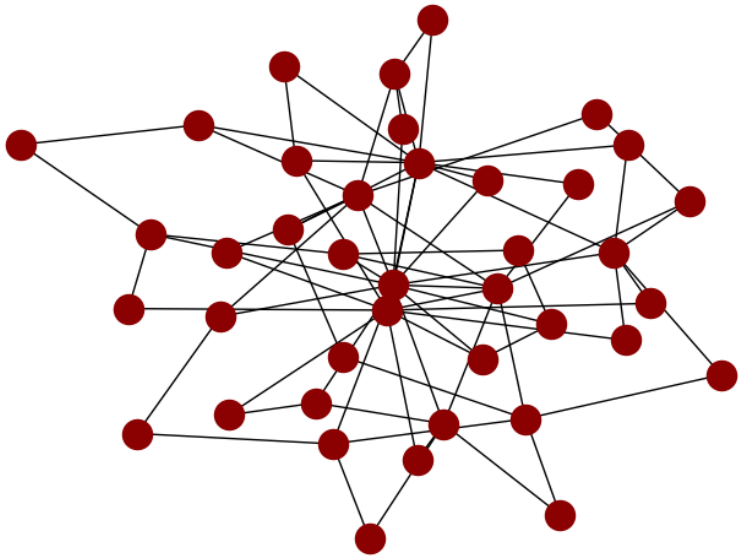
Population: 10,000



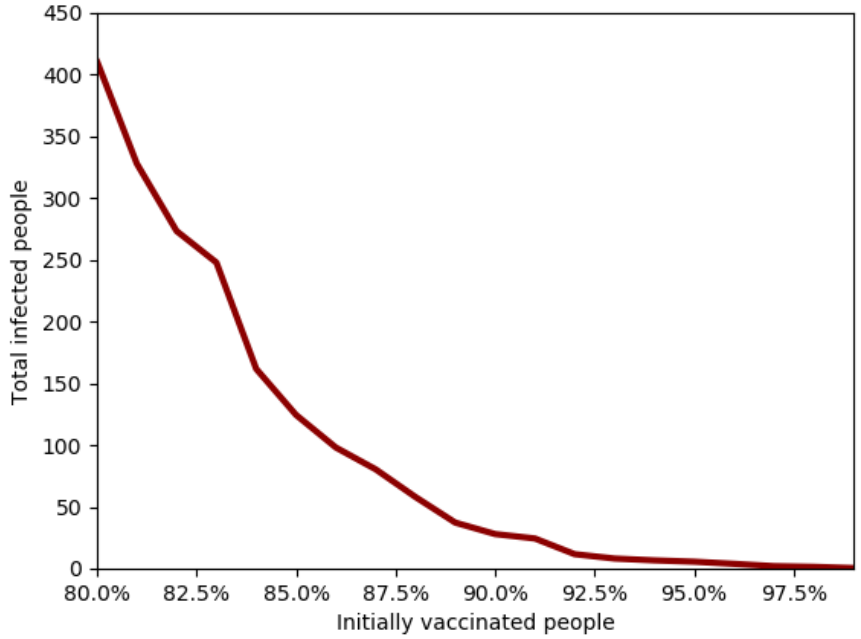


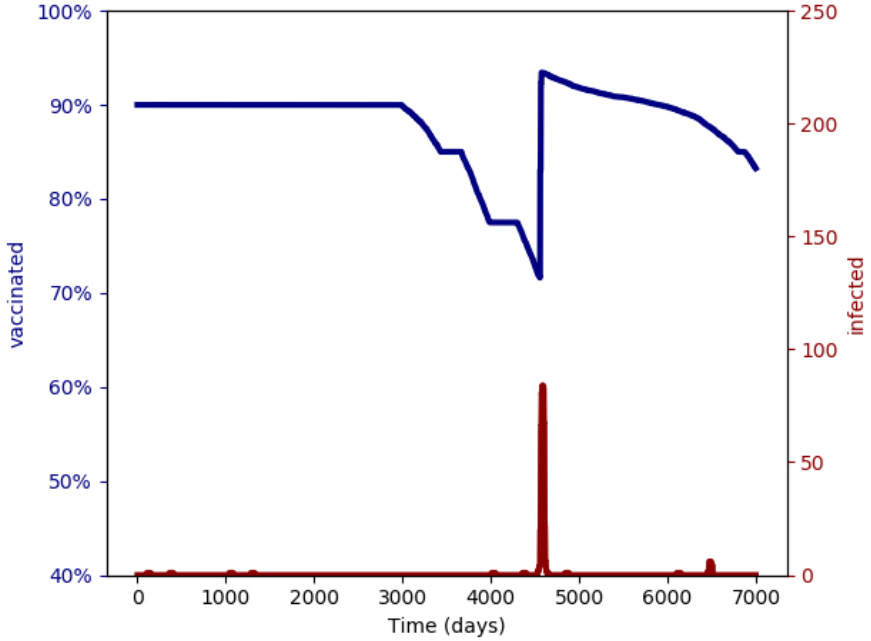
Pertussis resurgence

Summary



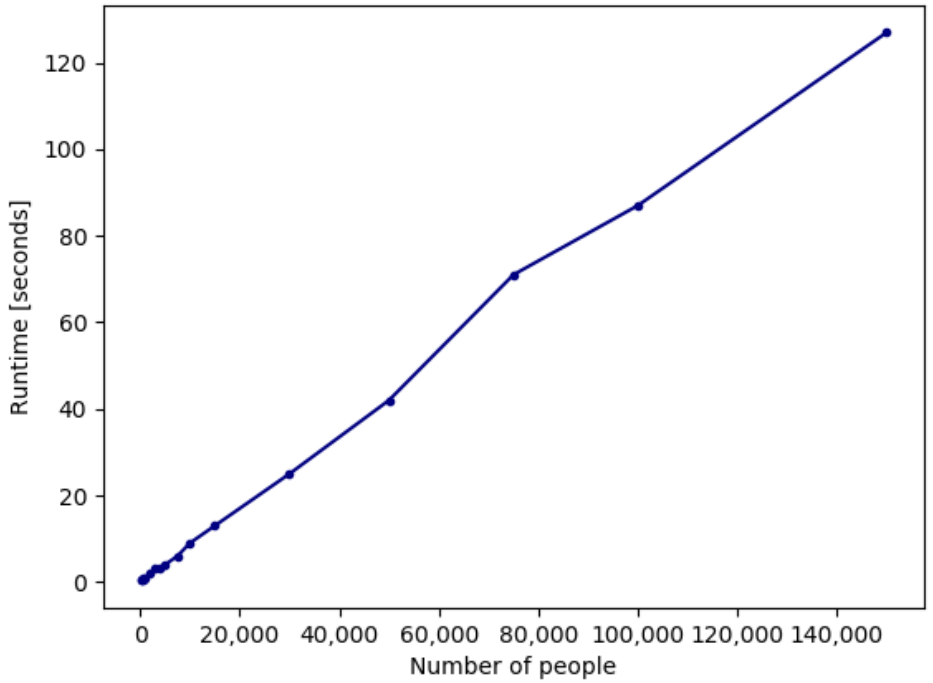
92%

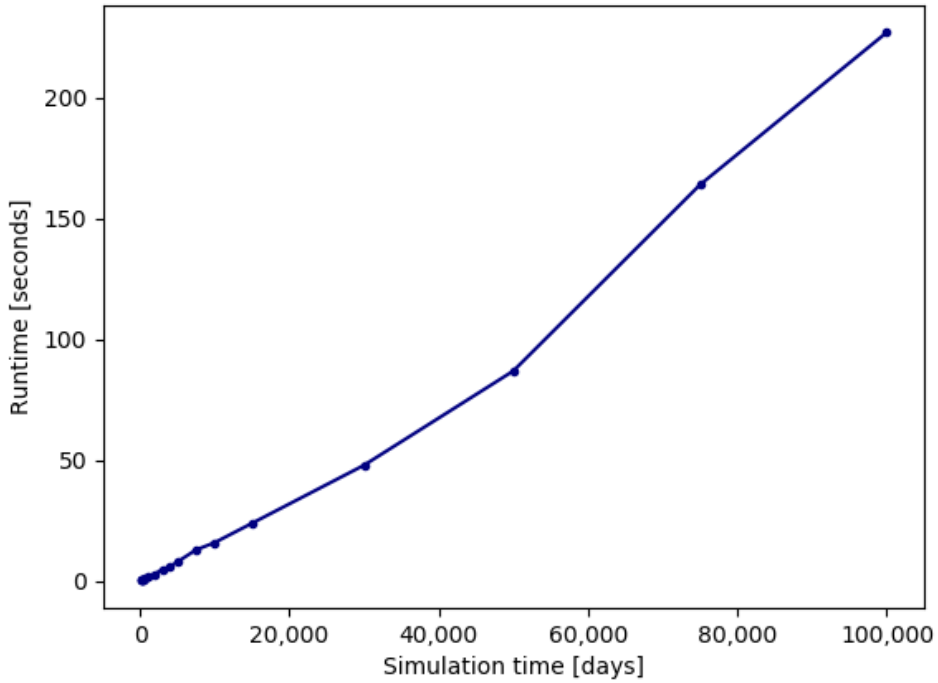




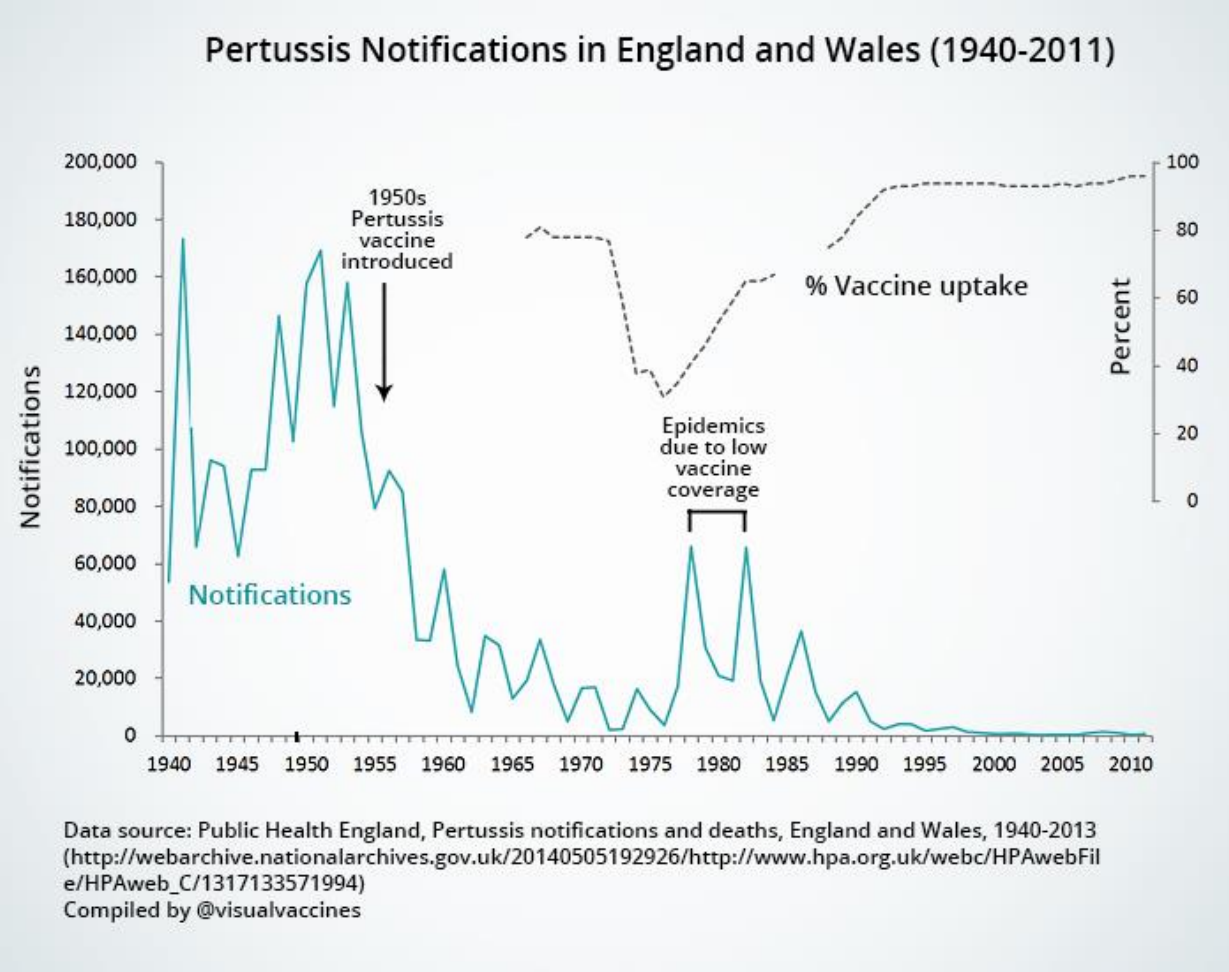
Pertussis resurgence

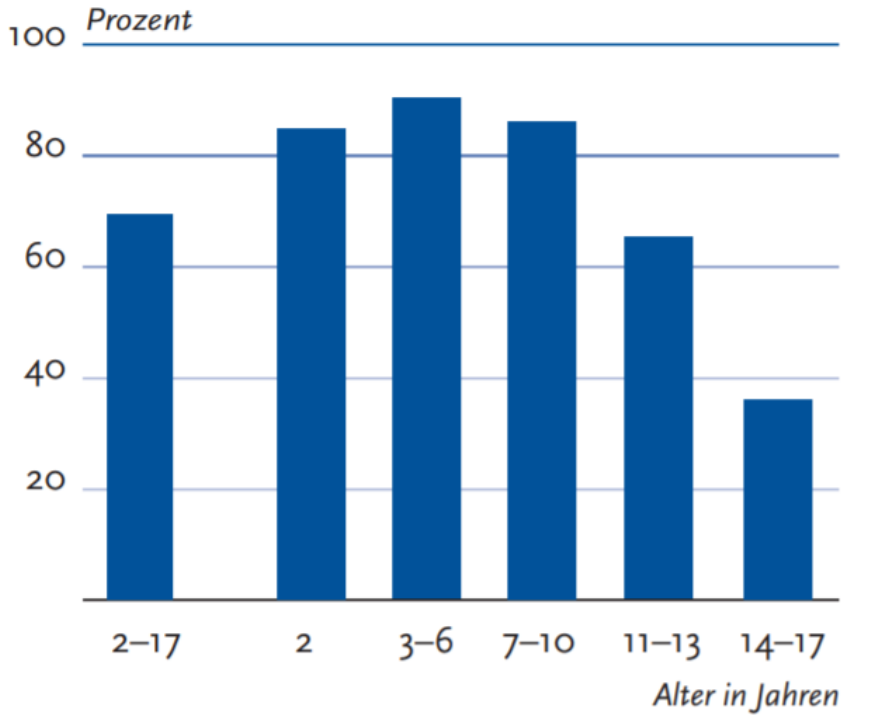
Additional graphs: runtime





Additional graphs: real data





Additional graphs: vaccination scares