

Simulating Vaccinations – Project Proposal

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Vaccines are without doubt one of the greatest advances in medicine, whose widespread use has led to the eradication or restriction of some of the deadliest diseases, including smallpox, polio and measles. Every vaccination carries a small risk of side effects. According to the WHO, severe adverse events are extremely rare for most vaccines (for the Hepatitis B vaccine only one in a million is affected) or not yet clinically proven like in the case of Hepatitis A.¹ However, contested medical papers and rumours have led to a reluctance to vaccinate in parts of the society.

The idea is the following: In a system with voluntary vaccination policies many people will vaccinate themselves against a dangerous disease. Consequently, the spread of the disease will decrease and so will the probability of getting infected for those, who are not vaccinated. That may lead to a point at which the perceived risk of possible side effects becomes larger than the risk of contracting the disease itself. In this case the individual will be reluctant to vaccinate, preventing the eradication of the disease on a global scale.

C. Bauch and D. Earn² have theorized that the likelihood for individuals to get or not get vaccinated can be described using game theory. Every individual wants to employ a strategy leading to the best possible outcome for themselves. It is generally expected that the choices of those strategies among the population converge to a stable Nash-Equilibrium.³

In our project we intend to simulate the behaviour of individuals using game theory and a SIR to model the trend of a disease. Every agent in our model tries to maximize their personal gain which is dependent on the perceived risk of side effects due to vaccination and the probability of infection, which itself is dependent on the number of vaccinated people. That means that the behaviour of one individual is affected by the behaviour of everyone else. The SIR, which is widely used in modelling the spread of diseases, will provide the parameters, several datasets on vaccination rates and effects of vaccination scares (UK 1970s pertussis, MMR starting 1998) will be used to test the model.

Using our model, we will simulate different scenarios to find out under which circumstances a disease can be eradicated and under which a decrease in the vaccination rate can lead to an uptake in infections.

Github repository: <https://github.com/hannahniese/simulating-vaccinations>

Bibliography and primary datasets:

Bauch, C. T., & Earn, D. J. (2004). Vaccination and the theory of games. *Proceedings of the National Academy of Sciences*, 101(36), 13391-13394.

Eshel, I. (1996). On the changing concept of evolutionary population stability as a reflection of a changing point of view in the quantitative theory of evolution. *Journal of mathematical biology*, 34(5-6), 485-510.

Heal, G., & Kunreuther, H. (2005). The vaccination game. Risk Management and Decision Processes Center Working Paper, (05-10).

<https://ourworldindata.org/vaccination> <https://www.gapminder.org/data/> search for 'vaccine'

Immunization coverage, system indicators and schedule, and disease incidence
http://www.who.int/immunization/monitoring_surveillance/data/en/

¹ WHO (2018-10-06) http://www.who.int/vaccine_safety/initiative/tools/vaccinfosheets/en/

² Bauch, Earn (2004), Vaccination and the theory of games

³ Eshel (1996) p.485