

Is legislating vaccination necessary?

An investigation of the combined effect of vaccine and quarantine of school classes using stochastic modelling

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Abstract

In this thesis we investigate an epidemic outbreak of a childhood disease in a population where many but far from everybody are vaccinated. This is a common situation and it is feared to be even more common as vaccine hesitancy and scepticism are on the rise.

Here we are interested in what effect an active response to an outbreak, taking the form of quarantine the unprotected population, might have on the spread of the disease. We consider the population to be divided into school classes, each individual makes contacts inside and outside the class at different rates. When an infection is detected the individual and all unvaccinated class mates get sent to quarantine. A recovered individual attains immunity, which gives our model similarities with a classical SIR model with household structure, but with an additional state of quarantine.

We derive expressions for the values of R_0 for a school class, which is independent of how many infected individuals there are inside it, the expected final proportion school classes that have had at least one infected individual and with the help of a result from a paper by Trapman and Bootsma from 2009 we get an approximate expression for the expected number infected individuals in a school class which leads us to an expression for the expected proportion infected individuals in the population.

Simulations show that the strategy is powerful, the disease reaches much fewer than when no quarantine is used, for example we have a situation where 40% are vaccinated in which 99% of the susceptible population get infected when we do not use quarantine of the school classes and when we use the quarantine strategy 1% get infected.

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