

# SIR Vaccination Model with Vital Dynamics

Vaccination of young children can be an effective measure against the outbreak of numerous diseases. Diseases like smallpox and polio have been effectively eradicated in the United States by the use of vaccines. In this problem, you will develop an SIR model with Vital Dynamics that models the vaccination of susceptible population. Using this model, you will try to determine the effect vaccination has on the disease and make suggestions on effective vaccination strategies.

## Background

Vaccination has been shown to be effective at preventing epidemics and eradicating endemic diseases in populations. Examples of the effectiveness of vaccines include the eradication of smallpox as well as dramatic reduction of poliomyelitis, malaria, measles, and rubella in North America and Europe.

## Some Model Requirements

- In the absence of vaccinations, the disease is modeled as a SIR-type disease.
- Susceptible are infected by the Infected at a rate proportional to the number of susceptible and infected.
- The infected group recover at a rate proportional to their population size.
- The population size is constant so the number of births and deaths in the population are equal.
- Deaths occur at the same rate in each group. (You can relax this assumption to better model diseases that increase the death rate for the infected)
- There is no vertical transmission of the disease from mother to child at birth.
- When there is no vaccinations, all birth are susceptible to the infection.
- When a vaccination program is introduced, the births are divided between susceptible and recovered. The fraction of births that are placed in the recovered is the vaccination fraction.
- Immunity is lost over time so the recovered become susceptible at a rate proportional to their population size.

## Some Questions to Answer

- How does the infection behave when there are no vaccinations when there is no loss of immunity over time? When there is loss of immunity over time? When is there an outbreak and when is the infection endemic?
- What effect does vaccination at birth have on the dynamics of the infection for both no loss and loss of immunity?
- Can vaccination prevent outbreaks?
- Can vaccination prevent the disease from becoming endemic?
- Does vaccination reduce the number of infected individuals?
- Can vaccination eradicate a disease?
- Does the model suggest an quantitative goal for controlling diseases?