March 4th 2024

Basic SIR Exercises

Basic SIR model

1. Starting with the code provided and using the deSolve package, model a measles epidemic using an SIR framework.
Run the model for a year in a closed community of 1 million individuals. Start the model with 1 infectious individual. Since measles is quite infectious, in this model we assume that on average, an exposed susceptible person has a .75 chance of getting infected if they come into contact with an infectious person. We also assume that an average person in a population of 1 million has about 12 respiratory contacts a week and that a person with measles remains infectious for about one week.
Hint: make sure all your parameters are coded using the same time units. Here, we will use **days**.
Also make sure that your time steps are in the same time units as your parameters.

Look at all three compartments (S, I, R) to see what happens over time.

2. Now let's consider two other infectious diseases of childhood – chickenpox and mumps. The probability of getting chickenpox if you have been exposed to an infectious person is .51. The probability of getting mumps if exposed is .38. Change the transmission probability first to .51 and then to .38 and observe the differences.

How does the course of these three infections differ in terms of timing, proportion of the community affected?

3. Let's assume we implement an intervention where infectious individuals with measles are isolated from others as soon as they develop symptoms. The mean duration of infectiousness is reduced to 3 days. Alter the measles model to reflect the practice of isolating individuals with symptoms.

How does this affect the epidemic trajectory?

SEIR model

4. In the model so far there is no latent period and the infectious period is identical to the duration of clinical disease**.** Now add a latent period to your model by adding a differential equation that says that among the infected there is a non-infectious state (E for exposed) before the period of infectivity begins. This is an SEIR model. In this particular model (again, representing measles), the latent period is 12 days long.

Write the new differential equation model and run it. How does the trajectory of the epidemic differ with the addition of the latent period?

Adding birth and deaths

5a. In a steady-state model, the number of births equals the number of deaths per unit time and population is constant. Add births and deaths to the SIR model from Question 1, so that we can study the behavior of simple epidemic in a steady-state situation rather than in a closed population, assuming that they are balanced. Use a birth and death rate of 0.013 per day.
Hint: Births only feed into the Susceptible compartment, while deaths occurs in each compartment in the model. Here, we make the simplifying assumption that individuals in the Susceptible, Infected and Recovered compartments all experience the same death rate.

Describe briefly what appears to be happening in terms of timing of the epidemics and the end-behavior in the open model.

5b. Does fertility affect epidemic behavior? In developing countries, both birth rates and mortality are higher than in wealthier countries. Increase the birth and death rate (keeping them the same) from .013 to .025.

Briefly describe the differences you see in the behavior of measles when fertility and mortality are increased graphically and in words.