Deterministic Epidemic Models with EpiModelWeb

Network Modeling for Epidemics
Day 1
EpiModel Web

- Web-based interface for simulating basic epidemic models
  - Currently available for deterministic and stochastic models
  - This tutorial will demonstrate modeling deterministic compartmental models and a stochastic “individual contact” model
    - Math and other details for ICM to come this afternoon
- We will launch this through the EpiModel package
Open Rstudio

library("EpiModel")

epiweb("dcm")
Deterministic SIR Model

• Use the following parameters for your first model
  - Model type = SIR
  - S = 1000; I = 1; R = 0
  - Transmission probability per act = 0.2; act rate = 1.4; recovery rate = 0.1
  - Press “Run Model” button

• Questions
  - What is \( R_0 \) for this infectious disease system? Does the epidemic “take off”?
  - What is the time step of peak incidence? Eyeball it with the Plot Selection set to Disease Incidence. Lookup the exact value in the Data tab. Hint: you can sort the columns, and si.flow is disease incidence.
  - Now do the same for disease prevalence (i.num). Why is the peak prevalence later than the peak time of disease incidence?
  - The net reproduction number, \( R_n \), is the natural reproduction number of the epidemic under conditions of \( I > 1 \). It tells us how close the epidemic is to the persistence threshold of over the course of the epidemic. It is calculated as: \( R_n = R_0 * (S_t/N_t) \)
  - Calculate that \( R_n \) for this epidemic at time steps 1, 20, the time of peak prevalence, and 60.
Deterministic SIR Model

• Change the model parameters
  - Model type = SIR
  - $S = 1000; I = 1; R = 0$
  - Transmission probability per act = 0.2; act rate = 1.4; recovery rate = 0.4
  - Press “Run Model” button

• Questions
  - What is $R_0$ for this infectious disease system? Does the epidemic “take off”?
  - What is the time of peak incidence and prevalence now?
  - Explain the logic (in words) why the epidemic trajectory changed related to parameter that you changed.
Deterministic SIS Model

• Change the model parameters
  - **Model type = SIS**
  - \( S = 1000; \ I = 1 \)
  - Transmission probability per act = 0.2; act rate = 1.4; **recovery rate = 0.1**
  - Press “Run Model” button

• Questions
  - What is \( R_0 \) for this infectious disease system (use the same calculation as for an SIR for simplicity, but consider why this is mathematically wrong too)? Does the epidemic “take off”? How does this epidemic signature look vs an SIR?
  - Pick a time when the prevalence has reached an “equilibrium state” (i.e., the slope of the prevalence curve is flat).
  - Under the Summary tab, enter this time step. Looking at the summary statistics in the table, and the flow diagram, explain why an equilibrium state for an SIS is occurring (hint: look at the flows!)
Deterministic SIS Model

• Change the model parameters
  - Model type = SIS
  - $S = 1; I = 0.001$
  - Transmission probability per act = 0.2; act rate = 1.4; recovery rate = 0.1
  - Press “Run Model” button

• Questions
  - What did we just do? How did scaling the population size down by a factor of 1000 substantively change your evaluations about the epidemic?
  - What would happen if we scaled up by a factor of 1000 ($S = 1$ mil, $I = 1000$)?
  - In general, for this model, how do the model results (absolute compartment sizes versus fractions/frequencies) depend upon the choice of population size?