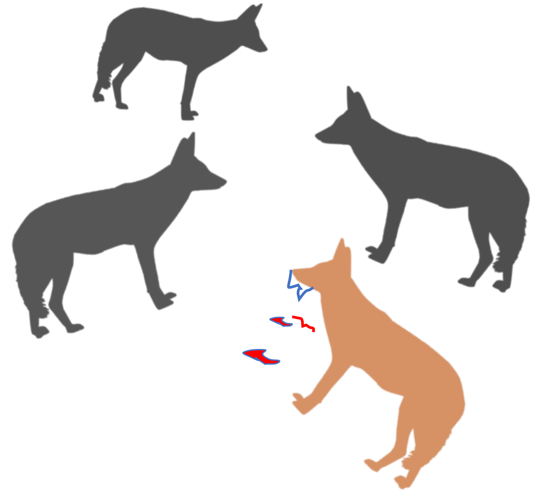
Lab: stochastic simulation models

Summary

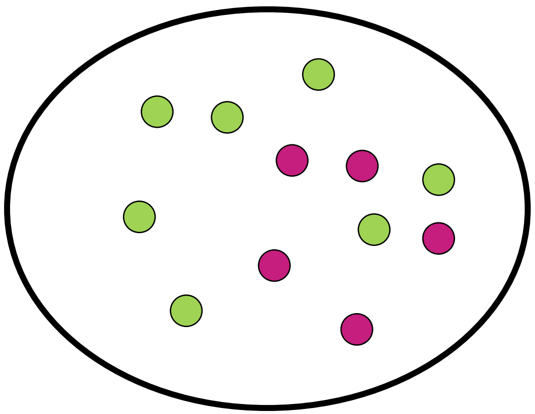
- The Gillespie algorithm is a continuous-time discrete-individual method for simulating stochastic epidemics.
- Each event is simulated separately and is characterized by an event time and a type of event.
- It may not be computationally feasible to use the Gillespie method, especially when the population size is large.

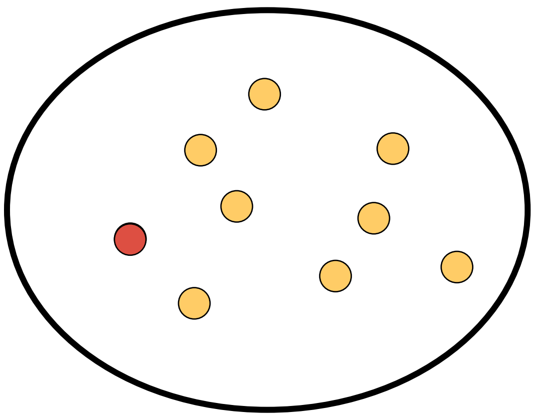
Rabies example



Maintenance population

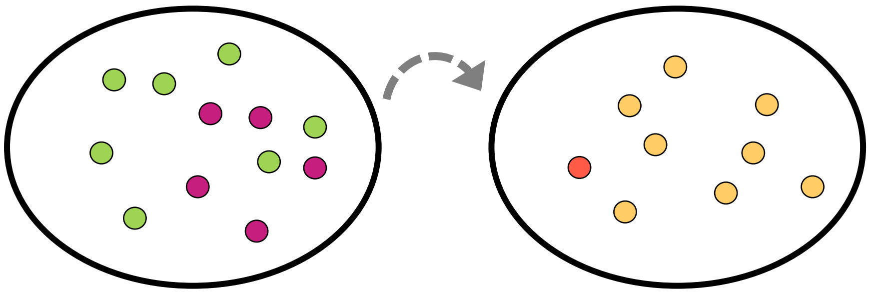
Target population





Types of transmission

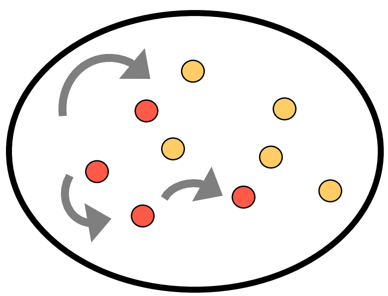
Spillover infections



Maintenance population Target population

$$I \rightarrow I + 1 \text{ at rate } \frac{\lambda S}{N}$$

Within-population



Target population

$$I \rightarrow I + 1 \text{ at rate } \frac{\beta S I}{N}$$

R code example

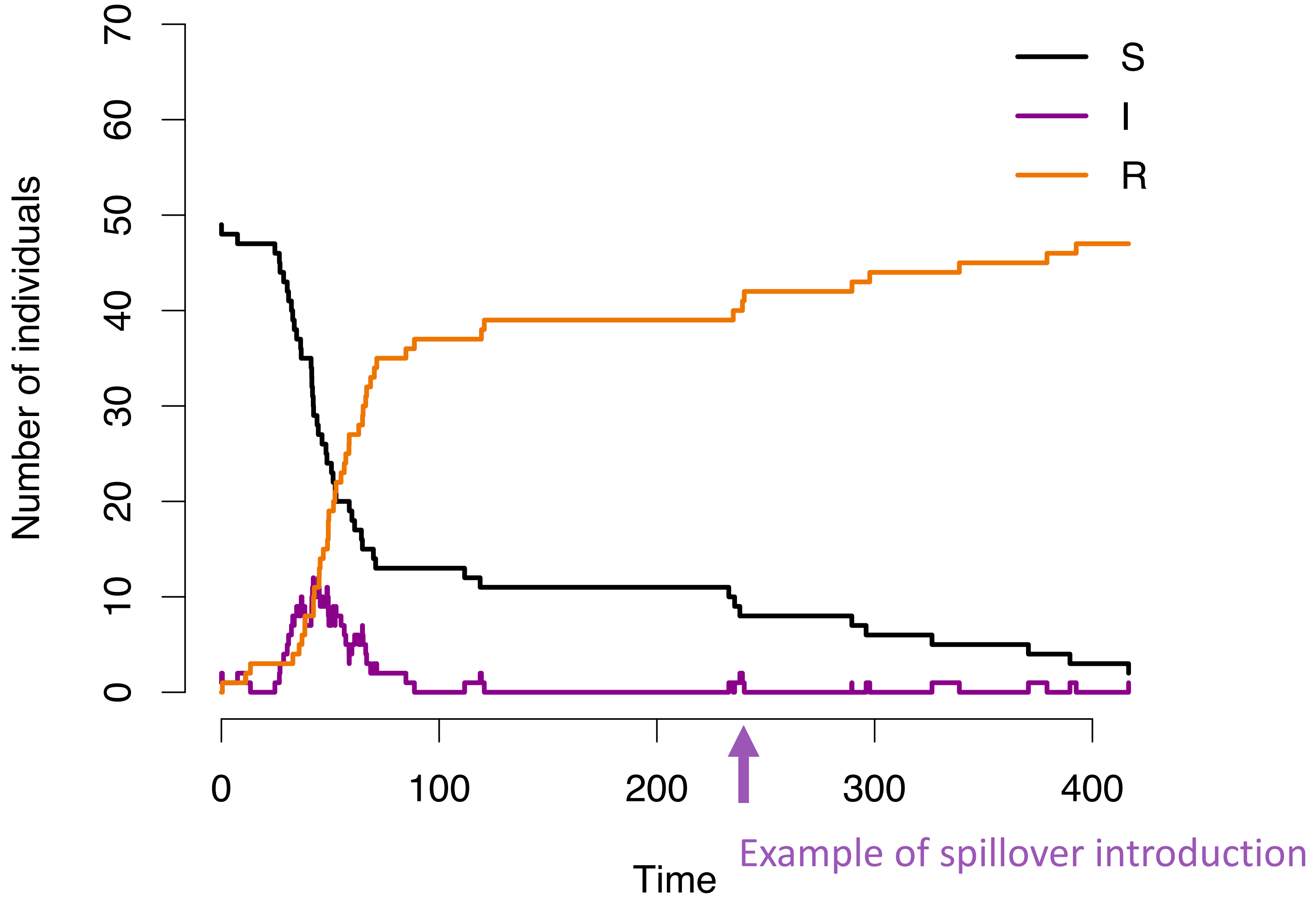
SIR model with spillover

Exercise 1: [Basic stochastic simulation models]

Try changing:

- population size
- spillover rate
- transmission rate
- recovery rate

Sample output

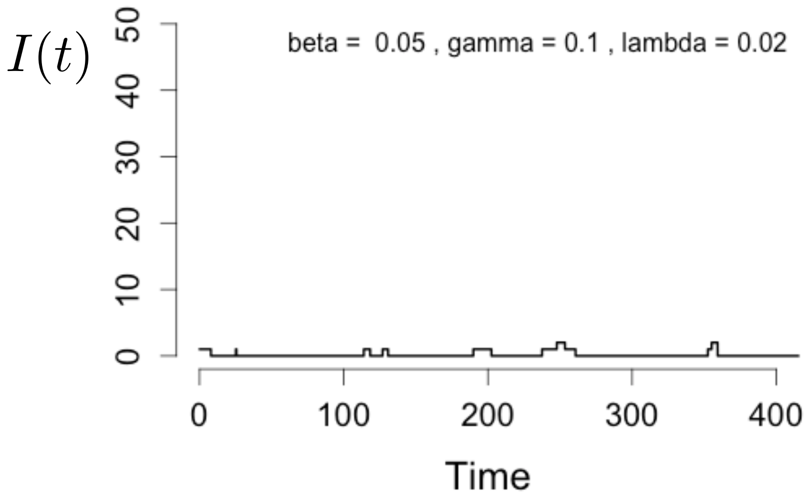


Sub-critical or super-critical?

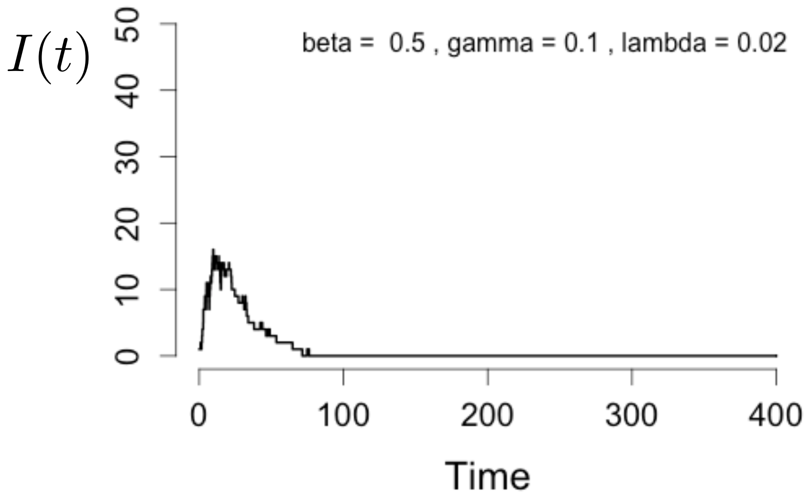
Basic reproduction number for SIR model:

$$R_0 = \frac{\beta}{\gamma}$$

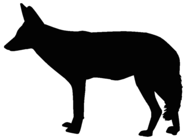
Sub-critical $(\beta < \gamma)$



Super-critical $(\beta > \gamma)$



Jackal rabies application



Parameter	Value	Meaning	Source
b	1	infection per week	Rhodes et al. 1998
ν	1.4	rabies related deaths per week	Rhodes et al. 1998
ρ	1	jackal density	Rhodes et al. 1998

$$R_0 = \frac{b}{\nu} = \frac{1}{1.4} \approx 0.7 \qquad \text{(rabies is sub-critical)}$$

Rhodes et al. (1998) "Rabies in Zimbabwe: reservoir dogs and the implications for disease control." *Philosophical Transactions of the Royal Society B*.

Question: how many additional infections are needed in order for rabies to be super-critical in the jackal population?

Borchering, Bellan, Flynn, Pulliam, and McKinley. (2016) “Resource-Driven Encounters and the Induction of Disease Among Consumers.” http://dx.doi.org/10.1101/091850 Submitted.

Title: **Stochastic simulation models tutorial**

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