Extending the SIR model to include compartments to assess health outcomes

MATHEMATICAL MODELING FOR INFECTIOUS DISEASE PLANNING IN AFRICA

(20 minutes)

UNIVERSITY OF Global Health EQUITY
HARVARD T.H. CHAN SCHOOL OF PUBLIC HEALTH
CENTER for COMMUNICABLE DISEASE DYNAMICS

Learning Objectives

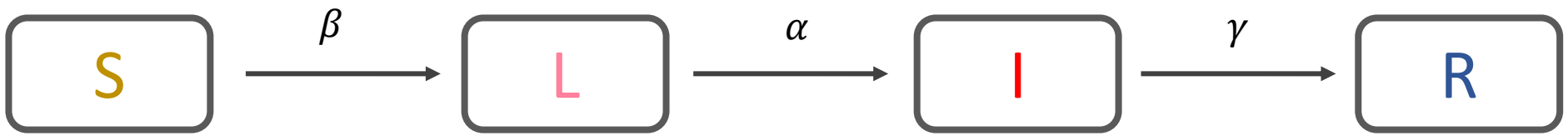
1. Identify health outcomes used to assess burden of a disease.
2. Understand how compartments can be added to assess health outcomes.

What are health outcomes?

What outcomes can be observed with a model?

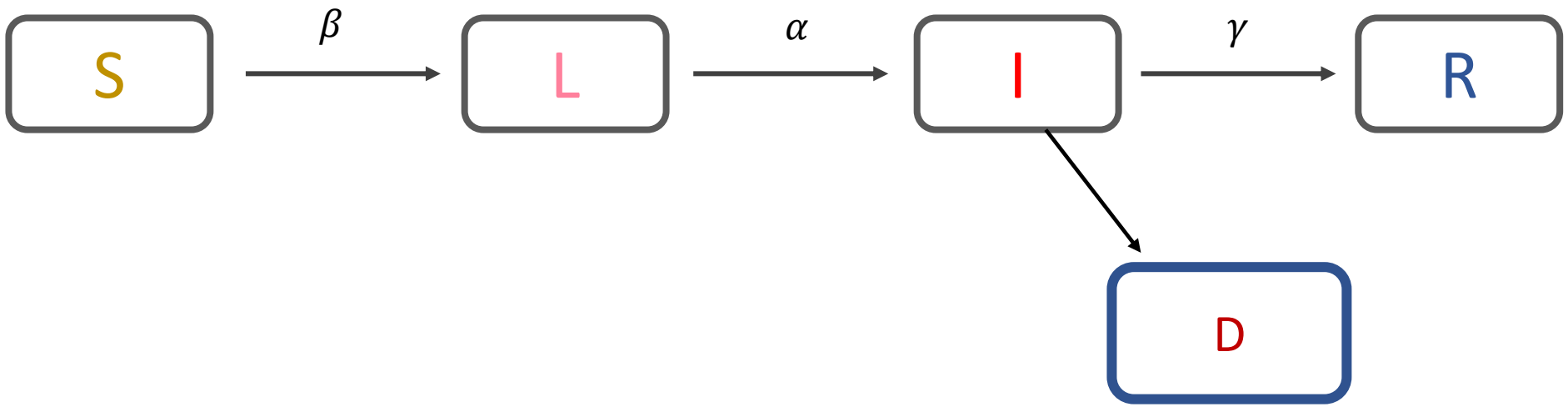
- How many people die from the disease?
- How many people were infected at the end of the outbreak?
- How many people are hospitalized?
- What is the peak size?
- How many waves are observed?
- What is the economic burden?
- Etc.

Example: Introducing a “D” compartment to a SLIR model



i. How would you introduce a Death “D” compartment to this model?
ii. How does the addition of the "D" compartment alter the model structure and equations?

Introducing a “D” compartment to a SLIR model



Introducing a "D" compartment to a SLIR model

- Model equations

$$\frac{dS}{dt} = \frac{-\beta SI}{N},$$

$$\frac{dL}{dt} = \frac{\beta SI}{N} - \alpha L,$$

$$\frac{dI}{dt} = \alpha L - \gamma \mathrm{I},$$

$$\frac{dR}{dt} = (1-q)\gamma \mathrm{I},$$

$$\frac{dD}{dt} = q\gamma \mathrm{I},$$

$$N = S + L + I + R + D.$$

What is q?

Case fatality ratio

How will you track the cumulative incidence?

UNIVERSITY OF Global Health EQUITY
HARVARD T.H. CHAN SCHOOL OF PUBLIC HEALTH
CENTER for COMMUNICABLE DISEASE DYNAMICS

How will you track the cumulative incidence (C)?

- The number of individuals in S or R at the beginning and end of the outbreak can be used to determine the total (cumulative) number of individuals that got infected during the outbreak.
- From equation?
  - $\frac{dS}{dt} = \frac{-\beta SI}{N}$,
  - $\frac{dL}{dt} = \frac{\beta SI}{N} - \alpha L$,

$$\boxed{\frac{dC}{dt} = \alpha L}$$

Why?

- Why is the cumulative incidence, C, not equal to $(\beta SI)/N$?

As you think through your outcomes…..

- “All models are wrong, but some are useful” – George Box

- “Everything should be made as simple as possible, but not simpler” – Albert Einstein
  - Your model structure should not be more complicated than necessary!