Types of Models

Modern Techniques in Modelling

LONDON SCHOOL of HYGIENE &TROPICAL MEDICINE

Many models, so little time

– **Model** is a generic term used to refer to a representation of reality, often (but not always) quantitative in nature.

– We use the term **mathematical models** to refer to a class of (quantitative) models that are **mechanistic** in nature.

– The opposite of mechanistic is **phenomenological**. Phenomenological models can be called **statistical** models to differentiate them from mathematical (mechanistic) models.

Many models, so little time

Mechanistic

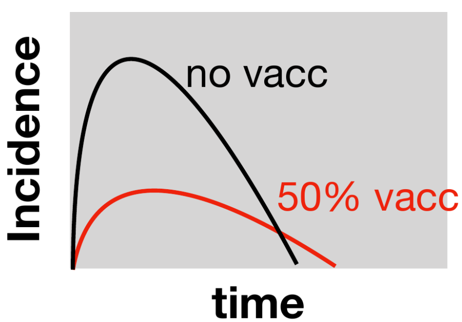
Variables are tracked through causal routes

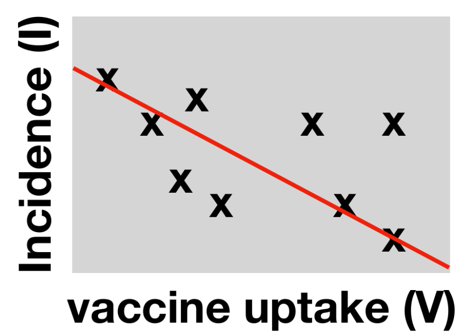
To understand how parameters and variables impact other variables

Phenomenological

Variables are tracked through association relationships

To understand how variables behave, not why they behave that way.





$$I = aV + b$$

Which models will we see in the course?

Difference equations

Tracks the number of individuals in each epidemiological “compartment” (e.g. Infected or Susceptible) at each e.g. day or week timestep

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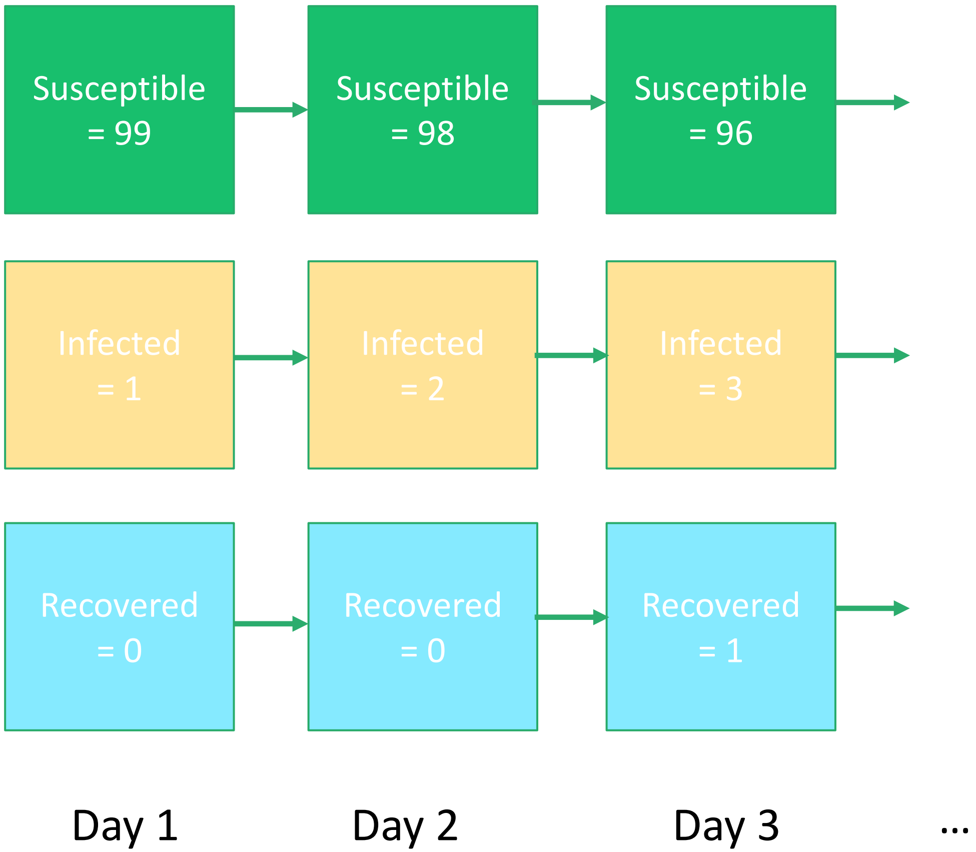

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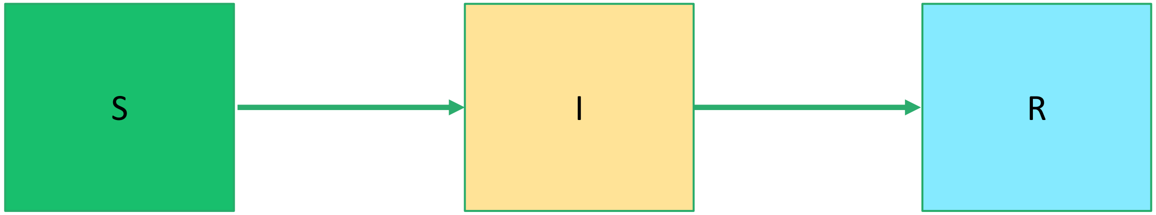
Ordinary Differential Equations (ODEs)

Same as 'difference equations' but instead of calculating at each timestep, we move to continuous time



Defined by change in the number of people in each compartment

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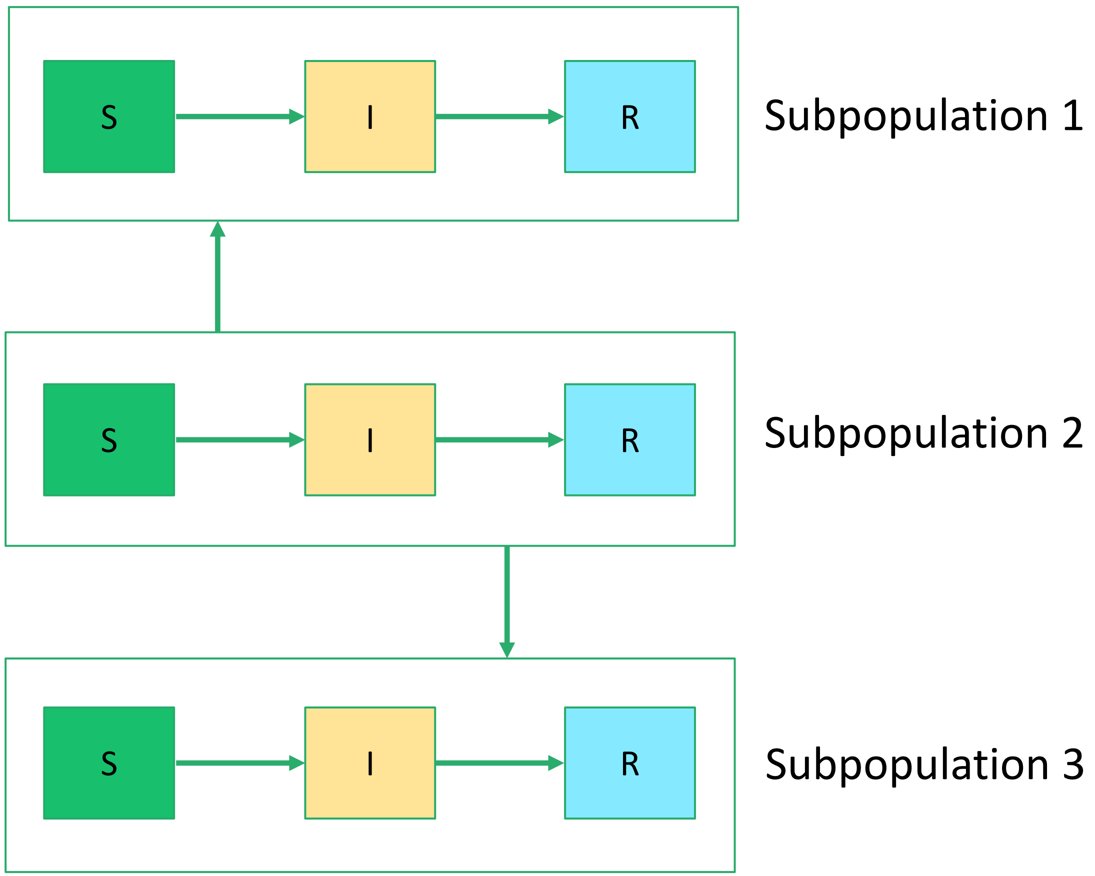

Metapopulation

Add in structure to ODE model by creating multiple subpopulations that can transmit infections within and between each subpopulation

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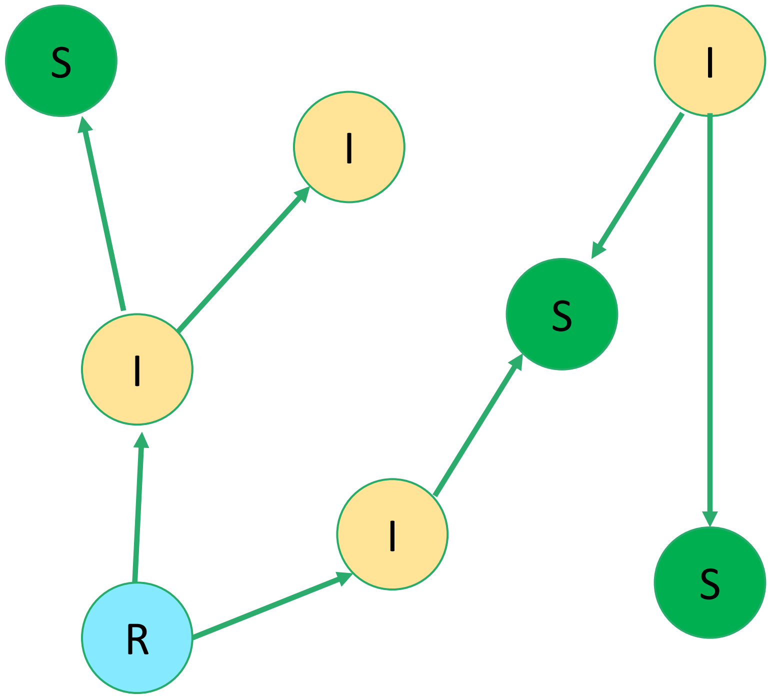


Network model

Elaborates on the idea of structure where each individual is constrained by who they can transmit to. This first introduces idea of "stochastic" dynamics

Which models will we see in the course?

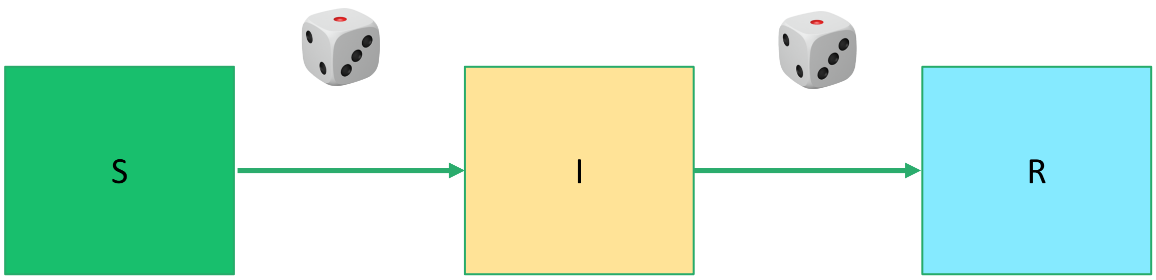
1. F 48.3y; became infected on day 16; has an incubation period of 5.2 days, will have mild symptoms and lose infectiousness after 8.6 days.

2. M 15.9y; became infected on day 102; has an incubation period of 3.0 days, will be hospitalized in North London on day 106, discharged on day 108 and lose infectiousness 10.6 days later.

Individual-based model (IBM)

Extends structure by tracking each individual, each with their own spatial and epidemiological characteristics

Which models will we see in the course?



Still defined by change in the number of people in each compartment.

But events (e.g. infections, recoveries etc.) happen stochastically.

Because we are still tracking total number of people and not individuals, it's quicker.

Stochastic compartment model

A stochastic implementation of our compartment ODE model but there is randomness in events happening

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What type of mathematical models should we build?

Main Question: how do we choose a model type and a model structure?

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- What is the research question?
- How big is the population?
- Are there stochastic fluctuations in the data that cannot be mechanistically accounted for?
- Do we need to track every individual?
- What type of events are we modelling and how do we parameterise them?
- What type of data do we have?

Terminology clarification

- **Model Variable**: A quantity that is tracked through time and changes as a function of the other variables/parameters (e.g. number of infected people)
- **Model Parameter**: Will stay constant through a whole iteration of a model (e.g. vaccine coverage, mortality rate)
- Note that in R parameters and variables are both sometimes called "variables”

Download practical exercises

All of the practical exercises will use R scripts that you can download in one go:

1. Open RStudio
2. Navigate to **https://github.com/cmmid/MTM** in your internet browser
   Follow QuickStart guide in README

To download your files:

Set path for new folder

```
MTM::scripts(path = "~/Downloads/MTM",
             overwrite = FALSE,
             what = "scripts")
```

Don't change this if you want to keep any files

Can change to 'solutions'