Modelling for Pandemic Preparedness and Response

Introduction to Infectious Disease Dynamics Modelling

Lecture Overview

This lecture introduces participants to some foundational concepts in infectious disease modelling, focusing on the basics of compartmental models, and especially the SIR model and its extensions (SEIR, SEIRV), and developing an understanding of the derivation and interpretation of the basic reproduction number, $R0$.

Prerequisites

Participants should have a basic understanding of calculus and differential equations, as well as some familiarity with the R programming language.

Course Materials

- Lecture slides
- R script templates for exercises
- Recommended readings and resources list

Learning Objectives

- An overview of infectious diseases and control.
- Foundations of infectious disease modelling.
- Introduction to compartmental modelling:

    - Implement and analyse homogeneous compartmental models (SIR and SEIR).

- Derive/calculate and interpret the basic reproduction number (R0).
- Introduction to models of infectious disease control:

– Implement and analyse models with control measures (SEIRV and SEIR + simple NPI).

- Incorporating heterogeneity in populations:

  – Models with age structure
  – Notes on other heterogeneities: spatial and network structure.

- Interpreting model parameters and outputs.
- Assessing model assumptions and limitations.

Course Schedule (subject to change)

Day 1

9:00 AM - 10:00 AM: Welcome and Introduction

- Overview of the course objectives and schedule.
- Introduction to infectious diseases and control measures.

10:00 AM - 10:15 AM: Morning Break

10:15 AM - 11:15 AM: Lecture - Foundations of Infectious Disease Modelling

- Basic concepts in infectious disease epidemiology.
- Historical context and development of infectious disease models.

11:15 AM - 11:45 AM: Exercise - Foundations of Infectious Disease Modelling

- Group discussion on historical infectious disease outbreaks.
- Identifying key epidemiological concepts in past outbreaks.

11:45 AM - 12:45 PM: Lecture - Introduction to Compartmental Modelling

- Basic principles of compartmental models.
- Introduction to SIR and SEIR models.

12:45 PM - 1:00 PM: Exercise - Introduction to Compartmental Modelling

- Simple implementation of an SEIR model using R.

1:00 PM - 2:00 PM: Lunch Break

2:00 PM - 3:00 PM: Lecture - Deriving and Interpreting the Basic Reproduction Number (R0)

- Theoretical derivation of R0.
- Calculation and interpretation of R0 in different scenarios.

3:00 PM - 3:15 PM: Afternoon Break

3:15 PM - 4:45 PM: Exercise - Deriving and Interpreting R0

- Comprehensive exercise: Implementing, running, and analyzing an SEIR models.
- Calculation and interpretation of R0 for different infectious diseases.
- Discussion of results and implications for public health decision-making.

4:45 PM - 5:00 PM: Q&A and Recap of Day 1

- Open session for questions and clarifications.
- Summary of the key points covered during the day.

Day 2

9:00 AM - 10:00 AM: Lecture - Introduction to Models of Infectious Disease Control

- Overview of control measures in infectious disease models.
- Introduction to SEIR models with vaccination and/or non-pharmaceutical interventions (NPI).

10:00 AM - 10:15 AM: Morning Break

10:15 AM - 10:45 AM: Exercise - Models of Infectious Disease Control

- Setting up SEIRV and SEIR + NPI models.

10:45 AM - 11:45 AM: Lecture - Implementing Models with Control Measures

- Detailed steps for incorporating control measures in models.
- Analysis of model modifications.

11:45 AM - 12:15 PM: Exercise - Implementing Models with Control Measures

- Practical session: Implementing an SEIR model with time-varying vaccination.

12:15 PM - 1:15 PM: Lunch Break

1:15 PM - 2:15 PM: Lecture - Incorporating Heterogeneity in Populations

- Introduction to age-structured models.
- Brief notes on spatial and network heterogeneity.

2:15 PM - 2:30 PM: Afternoon Break

2:30 PM - 3:00 PM: Exercise - Incorporating Heterogeneity

- Building a simple age-structured SIR model.

3:00 PM - 4:00 PM: Lecture - Assessing Model Assumptions and Limitations

- Discussion on common assumptions in infectious disease models.
- Identifying and addressing limitations in model applications.

4:00 PM - 4:15 PM: Break

4:15 PM - 5:15 PM: Extended Exercise - Comprehensive Modelling and Analysis

- Comprehensive exercise: Implementing control measures and heterogeneity in models.
- Analyzing and discussing the extended models' outputs.

5:15 PM - 5:30 PM: Q&A and Course Wrap-up

- Open session for final questions and clarifications.
- Summary of the course and key takeaways.