MMath research project: Exploring heterogeneity in uptake of disease control measures

Objectives

Efforts to curb infectious disease outbreaks usually comprise multiple interventions, each having a different action to limit spread. For example, vaccination can induce immunity providing protection against infection, whereas face coverings and social distancing mainly act to reduce the risk of transmission from infected individuals. Furthermore, the interventions may not offer complete protection and not be used by everyone in the population, with differing uptakes of each intervention possible.

To investigate the impact of heterogenous intervention uptake on outbreak dynamics, the student would develop a deterministic, compartmental SIR model. This would include two interventions, with one reducing an individual's susceptibility, and the other reducing transmission when infected. The population may then be grouped based on which of the interventions, if any, they use (four total intervention uptake combinations). Simulations would be performed using different stratifications of the population into the four possible intervention uptake options, with temporal and final size statistics analysed.

To enable an opportunity to undertake model fitting, the model may be used to generate synthetic data with known effectiveness parameters for the interventions. Given the synthetic data and the assumed model framework, inference methods (such as maximum likelihood, Markov chain Monte Carlo (MCMC) and/or reject-accept approximate Bayesian computation) may then be applied to obtain posterior distributions for the intervention effectiveness parameters. The aim would be for the known "true" parameter values, that were used to generate the synthetic data, to be contained within the inferred parameter posterior distributions.

Time permitting, the student would have the flexibility to steer subsequent model development to aspects of greatest interest to them, which may include:

- Adding a spectrum of case severity (asymptomatic, mild symptomatic, hospitalised, death).
- Incorporating age structure with age-specific intervention effectiveness.
- Having a third behavioural group whose uptake of an intervention depends on the epidemiological situation.

Outcomes

- Develop coding skills.
- Gain experience in processing, curating and analysing epidemic data.
- Begin building a research network by attending and participating in SBIDER group meetings.
- Opportunity to apply techniques presented in complementary MMath modules, such as Population Dynamics (MA4E7) and Epidemiology by Example (MA4M1), to a real-world problem.