

Epidemiological Modelling and Dynamics

Potentially together with any PI within WIDER <http://www.warwick.ac.uk/wider>

Background and Motivation

The spread of infectious diseases is one of the most studied processes in biology, with sets of well developed models, yet there is still much that we don't know, areas where there are mismatches between predictions and data, and questions over optimal control. In summary, while the subject area has strong foundations there is huge scope for creative research.

For this reason, this is not one project but several.

Potential Projects

Interested students should come and talk to me, and I'll try to match their interests to suitable projects. Examples of what could be attempted include:

Dynamics of 'swine flu' in schools

We have access to detailed pupil absence records for all schools in the Birmingham area during the swine-flu outbreak. This leads to a novel opportunity to study the impact of schools in amplifying this infection. Multiple approaches could be taken from modelling at a school-level (and matching to observed data) to a purely statistical analysis of the outbreak.

Impact of partnerships

Based around sexually-transmitted-infections, this project examines the dynamics of SIS-type infections in a population comprised of singles and partnerships. Given that partnerships need to form, infection needs to be transmitted and partnerships need to break to allow sustained transmission, how does this affect early-growth and equilibrium prevalence of infection.

Evolution in households

Competition between strains of infection is key to the evolutionary dynamics of diseases. However the vast majority of models assume simple random mixing. In this project, you should use methods recently developed to rapidly model spread within households and extend these to include multiple cross-reactive strains.

Social Contact Networks

Recent research in Warwick has collected a vast amount of data on the social interaction between individuals, allowing us to formulate local contact networks for each responder. Several projects are possible with this data, from a detailed statistical description of various aspects to simulation of infection spread (or flow of ideas) on this network.

Dynamics of seasonally forced infections

We know that age-structured models of measles with seasonal forcing due to school terms are highly effective at capturing the observed 2-year epidemics. In this project we extend these models to consider other disease parameters and quantify how the periodicity changes.

Persistence of seasonally forced infections: the critical community size

Stochastic seasonally-forced age-structured models of measles do an excellent job of capturing the persistence and localised extinction of measles outbreaks. Here two key questions could be addressed: (i) how does this pattern of persistence / extinction change for other disease parameters? (ii) what is the impact of adding extra structure, such as schools or homes?

Endemic Stability

There is an interesting concept in epidemiology known as endemic stability, which can be mathematically expressed as the existence of multiple stable equilibria. This has been explained in terms of age-structured dynamics, where a high prevalence of infection leads to infection at younger ages who are responsible for greater levels of transmission; conversely low prevalence leads to infection at older ages who transmit the infection less. The aim of this project is to assess the validity of the verbal argument by constructing the necessary mathematical models.

Models of Waning Immunity and Boosting

It is increasingly thought that many disease previously considered to confer complete and long-lasting immunity do not actually obey this idealized paradigm. Instead, immunity wanes over time, but is continually enhanced by 'boosting' whenever a potential infection event occurs. The aim of this project would be to develop suitable models for this type of dynamics and to assess the differences between this and the idealized view, with the potential to detect the impact of waning immunity in real data.

Skills

Students would benefit from skills in programming, modelling or statistics; but interest in the subject and a willingness to learn are by far the most important.

Previous projects can be found at:

http://www2.warwick.ac.uk/fac/sci/math/people/staff/matt_keeling/projects