

Mathematical modelling in biology and medicine: from cells to populations

In this talk, I shall give examples of mathematical modelling of HIV and malaria infections at the host-pathogen and population levels, and a health economics model for nutritional interventions against child stunting in low- to middle-income countries, developed for the World Bank.

The first model to be discussed is the so-called basic or standard model of viral dynamics, developed in the 1990s to study the within-host spread of HIV infection. I will show how a simple extension of this model can explain the onset of AIDS in untreated HIV disease.

Latently infected cells represent a significant barrier to cure of HIV infection by antiretroviral therapy (ART). The second example is an in-host model that estimates the impact of latency-reversing agents on the reservoir of latently infected cells in patients on antiretroviral treatment.

Malaria infection that results in severe complications and death occurs predominantly in young children, while adults gradually acquire resistance with repeated exposure. We used a combination of stochastic and deterministic mathematical modelling to understand which form of immunity is consistent with the rates of reinfection in adults and children, seen in the field study data.

Finally, I shall show a model of the propagation of stunting in the cohorts of children under five years of age due to malnutrition, and the effects of an optimised country health budget on child development, as applied to Bangladesh.