

MATH 4800 Research ideas

Cancer: When and how aggressively should it be treated? If a cancer grows somewhat like a disease within the body, how do we balance the benefits of therapy with the damage created by side effects? How does the age of the patient affect this decision?

Chickenpox/Shingles: How does shingles reawaken, and how does it differ from chickenpox? How and why is the vaccine different from the chickenpox vaccine? Is the current abundance of shingles due in part to the loss of constant boosting through exposure to chickenpox? Why does shingles typically appear only late in life, and why do some cases fail to resolve themselves?

Rabies: How does a vaccine work that is given after the infection? What is the course of infection? Is putting people in the freezer really a therapy?

Complex life cycles: Many pathogens persist in multiple hosts, such as malaria and toxoplasmosis. How can we extend models to include more than one host species? How does this affect the probability of disease extinction?

Antibiotic resistance: How can we model the evolution and control of antibiotic resistance in both bacteria and viruses? When does the resistance that develops in one host spread to the larger population? When will it spread beyond the hospital or smaller community?

Population genetics: Can we use the mathematical methods developed to model the spread of diseases to look at the spread of alleles of genes with higher fitness? How does a gene differ from a vertically transmitted disease? When will a pathogen evolve to help rather than harm its host?

Superspreaders and networks: In real populations, individuals differ in how susceptible they are, how effectively they transmit, and in how many contacts they have. Furthermore, real populations do not mix randomly but instead form some sort of network or graph. Can models with differential equations capture these effects? What mathematical methods are needed to study networks? How do networks and other forms of heterogeneity affect the probability that a disease goes extinct, or the number of hosts that survive an epidemic?

Tetanus: As with rabies, it seems like you can get the vaccine for tetanus after being exposed. What does the vaccine actually do and how does it protect against the toxin and against the bacteria?