CBS 810

Multi-strain models

1. Why is important to understand the interactions between strains?

Understanding interactions helps understand pathogen evolution. Multiple strains may compete to the extinction of one, or coexist through various mechanisms.

1. Explain what ‘complete cross-immunity’ means.

Either strain of a multi-strain pathogen can confer immunity against all the strains. Co-infection does not happen (competitive exclusion).

1. Explain the strain dynamics predicted by the model with complete cross-immunity

Since the strains provide complete protection from each other the strain with the largest R-naught drives the other to extinction.

1. Explain what the transmission-virulence trade off hypothesis is.

As the transmission rate increases the duration of the infection decreases, which following the theory leads to R-naught being maximized for intermediate values.

1. What mechanisms can favor co-existence of multiple strains?

Strain-transcending immunity, spatial-temporal epidemic dynamics, antigenic escape mutations, continual immune selection, the allee effect (reducing prevalence of one infection may reduce prevalence of the other).

1. Explain what ‘partial cross-immunity’ means.

Recovery from one infection provides some limited protection against related strains. Susceptibility and/or transmissibility may be reduced, with the response being either homogeneous or heterogeneous. Under partial cross-immunity, strains coexist when R-naught values are close to each other.

1. How is partial cross-immunity modeled in SIR models?

Partial cross-immunity is modeled using terms for the proportional reduction in susceptibility to each strain and the proportional reduction in transmission of each strain under conditions of co-infection. Mathematically, neither strain exists when both have R-naught values less than 1. The second strain can invade the equilibrium of the first strain (one with higher R-naught) if its transmission is still greater than zero then the transmission reduction factor is applied.