

Contribution ID: 348

Type: Oral Presentation

Investigating the dynamics of coupled epidemiological transmission models with application to Group A Streptococcus and Scabies

Tuesday, 10 July 2018 12:10 (20 minutes)

Infections with Group A Streptococcus (GAS) are highly prevalent in remote communities in the Northern Territory, Australia. One of the primary drivers of GAS infection is scabies, a small mite which causes a break in the skin layer, potentially allowing GAS to take hold. This biological connection is reaffirmed by the observation that mass treatment for scabies in these remote communities sees a reduction in the prevalence of GAS infection, despite GAS not being directly targeted. In the most extreme case, it has been hypothesised that the eradication of scabies in remote communities may lead to an eradication of GAS related infection.

We start by proposing a model of GAS transmission that assumes that scabies dynamics are at equilibrium. We assume that GAS follows a Susceptible – Infectious – Susceptible (SIS) structure, but individuals who are infected with scabies experience an increased force of infection compared to those who are not infected with scabies. In consequence, we are able to calculate the required prevalence of scabies required to ensure that GAS is eradicated, as a function of R_0 and the coupling strength between the two infections.

In order to more accurately model the impact of mass treatment for scabies, we extend this model to include the dynamics of scabies infections. We consider two different scabies models: one which includes the full dynamics of the scabies mites, and one which collapses these dynamics down to a far simpler phenomenological model. We investigate the difference in the scabies rebound dynamics after mass treatment for these two models, and consider the impact of this difference on the dynamics of GAS. We show that despite the two scabies models having different mean field dynamics, parameter uncertainty and the small population size mean that this difference is severely muted when considering the post-scabies treatment on GAS. Finally, we compute a value for the increased force of infection experienced by those infected with scabies, below which eradication for GAS would be achieved if scabies were eradicated.

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Session Classification: Epidemiology

Track Classification: Disease - infectious