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Pathogen spread on coupled networks: effect of host and network properties on transmission thresholds

In recent years network models have been extensively used to study how spreading dynamics in human populations, such as the dynamics of an infectious disease, a rumour or even a behaviour, depend on how individuals are connected to each other. Real populations are connected via a large variety of networks; respiratory, sexual or online social networks to name just a few. These networks, though generally of very difference structure, are not always independent and interactions on one may influence interactions on another. For example, HIV is spread over a sexual network and TB over a respiratory network, infection with HIV raises the risk of progressing from latent to active TB, potentially increasing transmission rates of TB across the respiratory network. Here we develop the theory behind network models. First we consider two processes spreading on two distinct networks. Process B spreads only over network b, but process A spreads over both networks, with a reduced transmission rate over network b. We examine how the amount of transmission of process A over network b affects the epidemic, and find that even a small amount of transmission across another network can greatly influence the epidemic size. Secondly, we consider how different host types in the population affect the epidemic threshold of a disease over one network. We apply these frameworks to our motivating example of HIV and TB.