098

Controlling infectious disease through the targeted manipulation of contact network structure

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Purpose:
Livestock populations are linked through dynamic contact networks with characteristic structural features that drive the epidemiology of directly transmissible infectious diseases. Using movement data from the British cattle industry as a case example, this analysis explores whether disease dynamics can be altered by placing targeted restrictions on contact formation to reconfigure network topology while still allowing farmers to engage in normal trade activities.
Methods:
This was accomplished using a simple network generation algorithm that combined configuration wiring with stochastic block modelling techniques to preserve the weighted in- and out-degree of individual nodes (farms) as well as key demographic characteristics of the individual network connections (movement date, livestock market, and animal production type). We then tested a control strategy based on introducing additional constraints into the network generation algorithm to prevent farms with a high in-degree from selling cattle to farms with a high out-degree as these particular network connections are predicted to have a disproportionately strong role in spreading disease.
Results:
Results from simple dynamic disease simulation models predicted significantly lower endemic disease prevalences on the trade restricted networks compared to the baseline generated networks. As expected, the relative magnitude of the predicted changes in endemic prevalence was greater for diseases with short infectious periods and low transmission probabilities.
Conclusions:
Overall, our study findings demonstrate that there is significant potential for controlling multiple infectious diseases simultaneously by manipulating networks to have more epidemiologically favourable topological configurations. Further research is needed to determine whether the economic and social benefits of controlling disease can justify the costs of restricting contact formation.
Relevance:
Network analysis offers a promising framework for developing control strategies that do not rely on diagnostic tests, antimicrobials, or biologics to reduce the prevalence of economically important livestock pathogens.