

DOCTORAL THESIS

Human disease-behavior interactions on complex networks models: incorporating evolutionary game into epidemiology

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Abstract

In the past decade, the study of disease dynamics on complex networks has attracted great attention from both theoretical and empirical viewpoints. Under such a framework, people try to predict the outbreak of disease and propose immunization mechanisms. However, this framework possesses a limitation, which makes it inconsistent with realistic cases. That is, this framework does not consider the impact of human behavior or decision-making progress on disease dynamic characters and prevention measures. To further resolve this problem, we in this thesis propose behavioral epidemiology based on game theory, which involves the interactions between disease dynamics and human behavior in complex networks. Motivated by realistic cases, we proceed with the research from theoretical models and consider the following aspects. We first re-construct a scheme of risk perception incorporating local and global information and show that this new evaluation scenario not only promotes vaccination uptake, but also eliminates the disease spreading. This interesting finding could be attributed to the positive feedback mechanism between vaccination uptake and disease spreading. Then, we introduce a self-protection measure, which, due to low cost, can only provide temporary protection. By simulations and analysis we show that this measure leads to multiple effects: contrary with cases of low (high) efficiency and cost of the self-protection measure, middle values drive more infection and larger cost, which is related to the loss of positive feedback between prevention measures and disease propagation. Subsequently, another scheme of adaptive protection is proposed, where a healthy agent can cut the connection with infected ones. We find that adaptive protection can effectively eradicate the disease and result in an optimal level of pruning infected links. Different from these proposals focusing on individual interest, we lastly study a subsidy policy from the viewpoint of population benefit. We find that disease can be well controlled with an increase of the vaccination level, while the total expense reduces. Taken together, these findings of the thesis further demonstrate that the interplay between disease dynamics and human behavior plays an important role in the control of diseases. The models presented in this thesis, especially combining with empirical data, may serve as a foundation for further investigation of the subject in the future.

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