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Using Agent-Based Modeling to Investigate the Existence of Herd Immunity Thresholds for Infectious Diseases on Randomly Generated Contact Networks

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Infectious diseases pose a serious threat to humans, plants, and animals. Though vaccines can help control outbreaks of infectious diseases, there is typically not enough vaccine available for the entire population. In this case, certain vaccination strategies can be employed to maximize the benefits for the entire population. Using results from graph theory and the simulation tool IONTW (Infections On NeTWorks), we investigated the effect of vaccinations on certain types of so-called contact networks that model the patterns of interactions within a population. In particular, we focused on a certain class of contact networks known as small world models, where individuals are randomly connected, i.e., can transmit and/or contract an infectious disease, along paths that are relatively small in relation to the overall population. These types of networks tend to provide good estimations of the interactions of real populations when the exact contact network is unknown. However, the complexity and stochasticity of such networks create challenges in determining the best vaccination strategy and how many vaccines should be deployed. We will discuss our results on how we used ABMs to investigate the existence of a herd immunity threshold, which is a fixed percentage of the population that we can vaccinate to minimize the possibility of major outbreaks of a given disease.

Keywords: Infectious diseases, agent-based modeling, herd immunity threshold, small-world networks, NetLogo, undergraduate research