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Epidemic Spread in Human Networks

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One of the popular dynamics on complex networks is the epidemic spreading. An epidemic model describes how infections spread throughout a network. Among the compartmental models used to describe epidemics, the Susceptible-Infected-Susceptible (SIS) model has been widely used. In the SIS model, each node can be susceptible, become infected with a given infection rate, and become again susceptible with a given curing rate. In this paper, we add a new compartment to the classic SIS model to account for human response to epidemic spread. Each individual can be infected, susceptible, or alert. Susceptible individuals can become alert with an alerting rate if infected individuals exist in their neighborhood. An individual in the alert state is less probable to become infected than an individual in the susceptible state; due to a newly adopted cautious behavior. The problem is formulated as a continuous-time Markov process on a general static graph and then modeled into a set of ordinary differential equations using mean field approximation method and the corresponding Kolmogorov forward equations. The model is then studied using results from algebraic graph theory and center manifold theorem. We analytically show that our model exhibits two distinct thresholds in the dynamics of epidemic spread. Below the first threshold, infection dies out exponentially. Beyond the second threshold, infection persists in the steady state. Between the two thresholds, the infection spreads at the first stage but then dies out asymptotically as the result of increased alertness in the network. Finally, simulations are provided to support our findings. Our results suggest that alertness can be considered as a strategy of controlling the epidemics which propose multiple potential areas of applications, from infectious diseases mitigations to malware impact reduction.

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