Biomathematics Seminar Series

Department of Mathematics and Statistics

Investigating Patterns of Disease Emergence in Stochastic Epidemic Models with Seasonality

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Changes in contacts during the school year or summer months and the effect of temperature or humidity on disease susceptibility are some of the proposed reasons for seasonal occurrence of infectious disease outbreaks. In order to formulate effective strategies for disease prevention and control, it is essential to comprehend the primary factors driving seasonal fluctuations and their interconnected dynamics. We examine how seasonal variation in transmission, recovery, or dispersal rates, their magnitude and seasonal synchrony or asynchrony impact the probability of disease extinction and time to disease extinction in several well-known continuous-time Markov chain (CTMC) SIR, SEIR multi- patch, and vector-host epidemic models. An ODE framework which incorporates periodic parameters for transmission, recovery, or dispersal serves as a basis for each stochastic model. The basic reproduction numbers and seasonal reproduction numbers from the ODE and branching process approximations of the CTMC are useful in predicting some of the stochastic behavior of the CTMC epidemic models. In particular, we apply these techniques to estimate a time-periodic probability of disease extinction, or equivalently, the probability of no disease emergence at the initiation of an epidemic. We also test the branching process approximations against simulations of the full CTMC epidemic models. The numerical outcomes show that seasonal variation in transmission, recovery, or dispersal generally increases the probability of disease extinction (reducing disease emergence) and the shape of the seasonal repro- duction number provides information about the shape of the periodic probability of disease extinction. However, extrema of seasonal probability of extinction precede those predicted by the instantaneous probability of extinction, a.k.a the “winter is coming” effect. These findings pave the way for the implementation of more effective disease mitigation strategies.

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