The Effect of Demographic Variability, Environmental Variability, and Periodic Fluctuations in Stochastic Epidemic Models

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Seasonality and contact patterns due to environmental fluctuations and social behavior affect the dynamics of disease outbreaks. Recent studies applied to deterministic and stochastic epidemic models with periodic environments have shown that the average basic reproduction number is not sufficient to predict an outbreak. We extend these studies to continuous-time non-homogeneous stochastic epidemic models with demographic variability, environmental variability, and periodicity to investigate the combined effect of periodicity and variability on disease dynamics for a vector-host epidemic model. The continuous-time nonhomogeneous stochastic processes have either discrete or continuous random variables. A multitype branching process approximation of the discrete vector-host model is used to calculate the probability of a disease outbreak with demographic variability and periodicity. The approximation follows from the solution of a system of differential equations which is derived from the backward Kolmogorov differential equations. The dynamics of the continuous vector-host model with demographic variability, environmental variability, and periodicity, a system of stochastic differential equations, is investigated numerically in terms of the dynamics near the endemic state. Extensions to other epidemic models with multiple patches will also be discussed.

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