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Recurrent and chaotic outbreaks in SIR model

We examine several extensions to the basic SIR model, which are able to induce recurrent outbreaks (the basic SIR model by itself does not exhibit recurrent outbreaks). We first analyze how slow seasonal variations can destabilize the endemic equilibrium, leading to recurrent outbreaks. In the limit of slow immunity loss, we derive asymptotic thresholds that characterize this transition. In the outbreak regime, we use asymptotic matching to obtain a two-dimensional discrete map which describes outbreak times and strength. We then analyse the resulting map using linear stability and numerics. As the frequency of forcing is increased, the map exhibits a period-doubling route to chaos which alternates with periodic outbreaks of increasing frequency. Other extensions that can lead to recurrent outbreaks include addition of noise, state-dependent variation and fine-graining of model classes.