Consequences of non-Markovian healing processes on epidemic models with recurrent infections on networks

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Infections diseases are marked by recovering time distributions which can be far from the exponential one associated with Markovian/Poisson processes, broadly applied in epidemic compartmental models. In the present work, we tackled this problem by investigating a susceptible-infected-recovered-susceptible model on networks with η independent infectious compartments ($SI_\eta RS$), each one with a Markovian dynamics, that leads to a Gamma-distributed recovering times. We analytically develop a theory for the epidemic lifespan on star graphs with a center and K leaves, which mimic hubs on networks, showing that the epidemic lifespan scales with a non-universal power-law $\tau_K \sim K^{\alpha/\mu\eta}$ plus logarithm corrections, where α^{-1} and μ^{-1} are the mean waning immunity and recovering times, respectively. Compared with standard SIRS dynamics with $\eta = 1$ and the same mean recovering time, the epidemic lifespan on star graphs is severely reduced as the number of stages increases. In particular, the case $\eta \to \infty$ leads to a finite lifespan. Numerical simulations support the approximated analytical calculations. For the SIS dynamics, where no immunity is conferred ($\alpha \to \infty$), numerical simulations show that the lifespan increases exponentially with the number of leaves, with a nonuniversal rate that decays with the number of infectious compartments. We investigated the $SI_\eta RS$ dynamics on power-law networks with degree distribution $P(K) \sim k^{-\gamma}$. When $\gamma < 5/2$ and the epidemic processes are ruled by a maximum k-core activation, the alteration of the hub activity time does not alter either the epidemic threshold or the localization pattern. For $\gamma > 3$, where hub mutual activation is at work, the localization is reduced but not sufficiently to alter the threshold scaling with the network size. Therefore, the activation mechanisms remain the same as in the case of Markovian healing.
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References

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