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A network epidemic model with preventive rewiring: comparative analysis of the initial phase

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Abstract

This paper is concerned with stochastic SIR and SEIR epidemic models on random networks in which individuals may rewire away from infected individuals at some rate ω, so-called preventive rewiring. The models are denoted SIR-ω and SEIR-ω, and we focus attention on the early stages of an outbreak, where we derive expression for the basic reproduction number R_0 and the expected degree of the infectious nodes $E(D_I)$ using two different approximation approaches. The first approach approximates the early spread of an epidemic by a branching process, whereas the second one uses pair approximation. The expressions are compared with the corresponding empirical means obtained from stochastic simulations of SIR-ω and SEIR-ω epidemics on Poisson and scale-free networks. For SIR-ω, and the SEIR-ω case without rewiring of exposed nodes, both approaches predict the same epidemic threshold and the same $E(D_I)$, the latter being very close to the observed mean degree $\overline{D_I}$ in simulated epidemics over Poisson networks. Above the epidemic threshold, pairwise models overestimate the value of R_0 obtained from the simulations, which turns out to be very close to the one predicted by the branching process approximation. For SEIR-ω where exposed individuals also rewire (perhaps unaware of being infected), the two approaches give different epidemic thresholds, with the branching process approximation being more in agreement with simulations.

Keywords: Network epidemic models, preventive rewiring, branching process, pair approximation.

1 Introduction

Interactions among individuals in a population can be described by networks of who-contacts-whom. Studies of contact networks in sexually transmitted diseases have long revealed a high variability in the number of contacts per individual and highlighted the importance of those individuals described as "super-spreaders" for the onset of an epidemic (1; 20). Similar conclusions about the importance of super-spread events were drawn