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Abstract In this paper we investigate the persistence and extinction of a stochastic epidemic model with a varying population environment in the long-term behavior. Our model consists of two stochastic differential equations: one for the susceptible individuals in which the transmission rate is disturbed by white noise, one for the exposed individuals in which the same perturbation occurs, and one ordinary differential equation in which describes the infective individuals in a varying population environment. We derive sufficient conditions for the extinction and persistence of the epidemic model depending on the constant contact rate. Moreover, we carry out several numerical simulations to illustrate the main results of this contribution.

Keywords Extinction · Persistence · Stochastic epidemic model · Varying population size · Random perturbation

Mathematics Subject Classification (2010) 60H10 · 37H10

1 Introduction

Some epidemic models assume that the population has a fixed size with constant birth rate and mortality (for example, see [1]-[4]). In these deterministic models, this assumption is often reasonable when diseases have limited effects on death rate and disappear in a short period. However, the real situations related to the population are always neglected for the sake of simplicity and approximation. For instance, the disease could spread virus easily in a wet (cold) environment rather than in dry (hot) surroundings or any other environment that may change randomly. Therefore, it is important to consider the disease dynamical behaviors under the random perturbations and varying population size environment. In recent years, there are many papers about this topic (see, for example, [5]-[10]).

In this contribution, we are about to focus on an susceptible-exposed-infective-susceptible model with varying population size and random perturbation. The basic assumptions associated with our model are listed below:

(A1) The total population $N(t)$ at time t is subdivided into three compartments, namely: susceptible, exposed and infective, denoted by $S(t), E(t), I(t)$ and $N(t) = S(t) + E(t) + I(t)$ varies with time t;
(A2) All parameters $b, d, \gamma, \lambda, \varepsilon, \alpha, \sigma$ are assumed to be nonnegative constants;
(A3) According to the assumption of stochastic SIS model formulated by [11]: the stochastic environment factor acts simultaneously on each individual in the population, we introduce stochastic environment

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