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# The social behavior and the evolution of sexually transmitted diseases

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**Abstract**

We introduce a model for the evolution of sexually transmitted diseases, in which the social behavior is incorporated as a determinant factor for the further propagation of the infection. The system may be regarded as a society of agents where in principle, anyone can sexually interact with any other one in the population, indeed, in this contribution only the homosexual case is analyzed. Different social behaviors are reflected in a distribution of sexual attitudes ranging from the more conservative to the more promiscuous. This is measured by what we call the promiscuity parameter. In terms of this parameter, we find a critical behavior for the evolution of the disease. There is a threshold below which the epidemic does not occur. We relate this critical value of promiscuity to what epidemiologists call the basic reproductive number, connecting it with the other parameters of the model, namely the infectivity and the infective period in a quantitative way. We consider the possibility of subjects to be grouped in couples.


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## 1. Introduction

In the recent years, many mathematical models of social phenomena have been formulated in order to describe a wide variety of phenomena [1]. A particular interest was shown by the evolution of epidemic processes when the structure of the underlying

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society is taken into account [2–5]. In many of these models the existence of a threshold value that determines the further evolution of a nucleus of infection was verified [6,7]. On the contrary, it is possible to find other situations where the absence of threshold was shown [6]. Nevertheless, the interesting feature in all of these models is that they incorporate a social aspect not taken into account in previous epidemiological analysis. In the present work, we analyze a particular family of diseases, those sexually transmitted such as AIDS, Hepatitis B, Syphilis, etc. We will focus on a particular aspect of the society very related to the propagation of these diseases: the sexual behavior. We will consider a society composed by sexually active individuals and with different behavioral patterns ranging from the most conservative or stable one, those who only have sexual intercourse with their stable and unique mate, to the most promiscuous who are continuously willing to change their sexual partner. The dynamic of the disease will be associated to the SIR case, where, at a given time, each individual in the population can be in one of the following three stages: susceptible (S), infective (I), and refractory or removed (R). A susceptible individual can become infective through contagion by an infective individual. Once an element has been infective, it enters a cycle that, after a fixed infection time, ends when the element reaches the refractory (or removed in case of death, as in the present model) state. At this stage the individual cannot be infected again or infect the others, therefore the infection ultimately leads to definitive removal of elements from the susceptible population. This family of models has been used to describe the dynamics of well-known infectious diseases, such as AIDS, rabies, and black death, by means of a mean field approximation [8].

## 2. The model

Our model of the society conforms to a set of $N$ sexually active subjects, which in principle are grouped in couples with the exception of a controlled proportion of singles ($\rho_{sng}$). At the beginning of the simulation a "promiscuity" value $p_i$ is randomly assigned to each agent from a semi-Gaussian distribution of width $\hat{p}$. $p_i$ determines the individual's tendency to dismiss its stable mate and go out—or just to go out in the case of the singles—to look for an occasional intercourse. In terms of the model the individual promiscuity $p_i$ is the probability of trying to meet somebody else on each opportunity, determined by the time step of the simulation. Then, a susceptible individual can become infective, after a sexual intercourse with an infective one, with probability $\beta$. The infective individuals remain infectious for a period $\tau$, after which they are removed by death.

Every time step, each individual must choose to have sex with their couple or with somebody else, the latter occurs with probability $p_i$. Those who have decided to go out, must choose a partner at random and if the latter has decided to go out too, the occasional couple is made. Therefore there is no social structure a priori. The web of contacts is constructed dynamically during the simulation depending on the percentage of singles and $\hat{p}$. Thus, a random proportion of subjects, from those who have decided to go out, are reorganized in temporary couples every time step. Those who were abandoned by their couples and decided no to look for another partner will not have