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Modeling the effect of police deterrence on the prevalence of crime in the society

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ABSTRACT

In this paper, a nonlinear mathematical model has been proposed and analyzed to study the effect of police force in controlling crime in a society with variable population size. In the modeling process, it is considered that immigration rate of susceptibles as well as criminals, is altered by police force. It is considered that the police force not only captures the criminals but also lessen their inflow in the region under consideration. A particular case of the proposed model has also been analyzed by assuming that there is no immigration of criminals into the society. The model analysis reveals that by ceasing immigration of criminals and maintaining a sufficient number of baseline police force, the crime in the society can be controlled completely. An explicit expression for critical number of baseline police force has been derived analytically. Numerical simulation and sensitivity analysis is also carried out to investigate the influence of certain key parameters on the dynamics of crime in the society.

1. Introduction

Nowadays more open boundaries have made the immigration of criminals easier than ever before. Due to globalization, crime has evolved rapidly and taken the transnational form [1]. In the western countries, the immigrant crime has become a major issue for public and political discourses [2,3]. Studies also suggest that immigrants are more likely to commit crimes than non-immigrants and thus when immigration increases in a country, crime increases as well [4]. Due to this, the public and policy makers have always been concerned about preventing the immigration of criminals. In the colonial period also, there were strict laws to restrict the arrival of criminals in a country. To combat the problem of immigrant crime, U.S. Immigration and Customs Enforcement (ICE) has employed Criminal Alien Program (CAP) that identifies, detains and initiates removal proceedings against criminal aliens [5]. Besides the immigration of criminals, there are several other factors responsible for prevailing crime in the society. Criminologists have explored a wide range of factors those attribute to commit crime. According to the theory of differential association in criminology [6], the criminal behavior is learned and it is learned in interaction with other delinquent persons. It is often observed that persons who interact with criminals or offenders are likely to acquire the same trait as well. These interactions induce the criminal tendencies in the people and encourage them to get involved in criminal activities [7,8].

The intervention which is always associated with crime is *punishment*. The purpose of punishment is to incapacitate criminals from society and have a deterrence effect on other possible offenders. Punishment is supposed to make criminal behavior less attractive and more threatening. Also, the punishments like capital punishment or imprisonment prevent the

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criminals to commit crime [9,10]. Becker [11], has suggested that people drift towards criminality when the benefits of crime are more than potential punishment. The presence of police increases the chances of punishment and hence the expected cost of committing crime. The police deterrence serves as an effective avenue to control the criminal activities [12]. Proactive policing lessen the crime rate and foster effective crime control [13–16]. But the mere presence of the police force is not enough for maintaining law and order in the society. For effectual prevention of crime, the increment in the police force should be made with the upsurge in crime rates. It is evident from the literature that the increased level of police has a substantial effect to reduce crime in society [17–19]. Hence, making additional recruitment in the police force in accordance to the level of crime in the society is a rational strategy for crime control.

For devising new strategies to control crime, mathematical modeling is emerging as a promising field. The results obtained from the models are expected to give new dimensions to the study of criminology and help policy makers to deal with different aspects of crime. Some researchers have adopted the approach of population dynamics to explore the influence of sociological and economic factors on the evolution of criminality [20–24]. In particular, Zhao et al. [21] have proposed a mathematical model to study the interplay between criminality and poverty and explored the possibility of crime control via government interventions. Recently, Shukla et al. [25] have investigated the effect of technology as a control measure for prevailing crime in the society. They found that increase in the level of technology decreases the equilibrium density of crime burden.

Many of the social problems are assumed to be contiguous like an epidemic [26,27]. Hence, the epidemic modeling approach can readily be applied to study the dynamics of crime in a society. Voluminous literature is available on epidemic models comprising the transmission and control of infectious diseases [28–31, and references therein]. Some of epidemiological studies have also focused on the effect of immigration of infectives on the dynamics of disease [32–37]. Using the same approach, a mathematical model to asses the effect of police on the prevailing crime in the society is proposed. It is considered that criminals in the society increase by two ways; either criminals immigrate from outside the region under consideration or people living in that region get involved in criminal activities due to contact with criminals. Further, it is assumed that police force deter the criminals and lessen the level of crime by restricting the arrival of criminals as well by incarcerating them. After completing the imprisonment, some criminals recidivate and some become susceptible again.

2. Mathematical model

Let us consider a region with population N, at any time $t > 0$. This population 'N' is divided into two classes according to the individuals' status with respect to the criminality. First class comprises susceptibles 'S', i.e., people who have not committed any crime so far but are prone to criminality. Second class consists of active criminals 'C', who are involved in various criminal activities. Then the alterations in the susceptible and criminal populations can be depicted as:

$$\begin{aligned}\frac{dS}{dt} &= (1-q)A - \frac{\beta SC}{N} - dS,\\ \frac{dC}{dt} &= qA + \frac{\beta SC}{N} - (\alpha + d)C.\end{aligned} \tag{1}$$

Here, A is the constant immigration rate of individuals in the region under consideration. It is assumed that, out of these immigrants a fraction q are criminals where as remaining fraction $(1-q)$ are susceptibles. It is assumed that a person in the susceptible class becomes a criminal due to the interaction with active criminals. The term $\beta SC/N$ is the conversion rate of susceptibles to criminals due to interaction, where constant β represents the transmission rate of criminality. The constant d is the outflow rate of people due to natural mortality or emigration. Further, it is considered that individuals involved in various criminal activities experience an increased rate of mortality due to homicides and other crime-associated risks. Hence, the constant α is crime-associated death rate.

Whenever criminal activities become prominent, the police force makes substantial efforts to maintain the law and order in the society. In view of this, the police force has been incorporated explicitly in the modeling process. Let us consider that the number of individuals serving the police force at time t is 'P'. It is assumed that police force would use twofold approach to deter the level of crime in the society. It is assumed that police prevents as well as controls the number of criminals in the society in the following manner:

(i) The police force limits the immigration of criminals in the region under consideration by securing the border. This implies that the fraction of immigration in the criminal class, i.e., 'q' now becomes a decreasing function of police force P. Let us denote this function by ρ, then it is given by

$$\rho(P) = q\left(1 - \frac{aP}{K+P}\right).$$

Here, a is the efficacy of police force in controlling immigration of criminals, so its value lies between 0 and 1, i.e., $0 < a < 1$, and constant K limits the effect of police force. It is noted here that

$$\rho(0) = q \quad \text{and} \quad \rho'(P) < 0.$$