Applied Computing and Informatics (2016) **12**, 154–160

Saudi Computer Society, King Saud University

Applied Computing and Informatics

(http://computer.org.sa)
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www.sciencedirect.com

ORIGINAL ARTICLE

Measurement of repeat effects in Chicago's criminal social network

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Received 1 November 2015; revised 11 January 2016; accepted 11 January 2016
Available online 14 January 2016

KEYWORDS

Crime analysis;
Social network analysis;
Violent crime;
Predictive policing

Abstract The "near-repeat" effect is a well-known criminological phenomenon in which the occurrence of a crime incident gives rise to a temporary elevation of crime risk within close physical proximity to an initial incident. Adopting a social network perspective, we instead define a near repeat in terms of geodesic distance within a criminal social network, rather than spatial distance. Specifically, we report a statistical analysis of repeat effects in arrest data for Chicago during the years 2003–2012. We divide the arrest data into two sets (violent crimes and other crimes) and, for each set, we compare the distributions of time intervals between repeat incidents to theoretical distributions in which repeat incidents occur only by chance. We first consider the case of the same arrestee participating in repeat incidents ("exact repeats") and then extend the analysis to evaluate repeat risks of those arrestees near one another in the social network. We observe repeat effects that diminish as a function of geodesic distance and time interval, and we estimate typical time scales for repeat crimes in Chicago.

1. Introduction

Criminological studies have shown that crime is not uniformly distributed among victims, arrestees and places, with repeat crimes playing a fundamental role [5]. In fact, about half of all crimes in the United States are committed by repeat arrestees [19]. Moreover, some reports [4] have suggested a high degree of overlap between victim and arrestee populations, and research has already demonstrated that victims of personal or property crimes and of gun violence experience elevated crime risks within months of an instigating incident [8,16]. Thus, it is reasonable to expect the same effect to exist

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Peer review under responsibility of King Saud University.

ELSEVIER Production and hosting by Elsevier

http://dx.doi.org/10.1016/j.aci.2016.01.002

among the arrestee population, which has implications for the prevention of crime [10,21].

In the field of criminology there is a well-known phenomenon known as the *near-repeat effect*, which refers to a tendency for crime risk to be temporarily increased within the near vicinity of recent crime incidents (i.e., incidents that have taken place nearby in both space and time; e.g., [10,20]).

In this paper, we hypothesize the existence of a different kind of near-repeat effect, in which we modify the definition of "near" to refer not to geographical relationships among crime incidents, but rather to crime-related interpersonal relationships among the individuals involved in these incidents. We measure the notion of interpersonal distance by using the well-established concept of "degrees of separation," which is known technically as *geodesic distance*. In this paper we define geodesic distance in a criminal social network as follows: If Person A and Person B have been arrested previously in connection with the same crime incident (*co-arrested*), they are said to have one degree of separation. If, in turn, Person C has been co-arrested with Person B, then Person C is said to be separated from Person A by two degrees, and so on. Thus, we hypothesize that a crime incident involving Person A, will temporarily increase the crime risk for individuals such as Persons B and C, who are near Person A in this specific sense that we have defined. Later we show that the hypothesized effect does indeed exist within crime data for the city of Chicago.

The immediate motivation for our study is to inform an ongoing collaborative effort between the Chicago Police Department and our research team at the Illinois Institute of Technology. In this initiative, we have successfully developed and deployed prediction algorithms that estimate the risk of future violence for persons with extensive criminal records. We anticipate that our prediction algorithms will be enhanced by exploiting the probabilistic relationship, if it exists, that would be implied by the aforementioned interpersonal near-repeat effect. Thus, the present work not only informs our fundamental understanding of crime behavior, but is also expected to have practical implications for the prediction of crime, which is a rapidly emerging field [18]. We next review basic concepts of the near-repeat effect and social networks so as to place our work in context.

Repeat crimes may occur for various reasons, including event dependence linked to the psyche, actions, and environment of arrestees [10], with some facet of the arrestee's previous experience increasing the chances of participation in a subsequent incident, with the possibility of the effect spreading to others in the same environment and social groups as the original arrestee [16]. With victims and arrestees tending to belong to similar populations, event dependence suggests the formation of crime patterns establishing positive feedback, eventually escalating into situations involving an excess of dangerous persons or groups, and areas of high crime density. Effective policing strategies would identify these situations as they are forming, thus ceasing the spread of further crime.

Repeat crimes can be characterized as either *exact-repeat* or *near-repeat*, depending on whether consecutive incidents occur at the same location, or at a nearby location. [10] considered the spread of repeat effects to neighboring locations by using Monte Carlo methods to determine the likelihood of the observed patterns occurring if no correlation between spatial and temporal distributions exists. Similarly, Ratcliffe and Rengert [20] investigated repeat effects in shootings in Philadelphia, PA, using a modification of a standard Knox test [12]. Short et al. [22] showed that repeat effects exist among burglaries in Long Beach, CA, and further showed that these effects decrease with distance in space and time.

Social networks have recently been used to investigate the influence that an individual has on his peers [16,17]. There are many reasons to suspect the spreading of repeat effects in a criminal social network. First, many violent crimes are driven by emotions created by social relationships and thus occur between persons who know one another [9]. Second, conditions favoring the participation in crime incidents are spread through peer influence [7]. Third, physical objects such as drugs or weapons are usually dispersed through interpersonal connections, implying that the illegal selling and use of these objects also occur through these connections [6].

For the remainder of this paper, we will present repeat analyses on crimes that occurred in Chicago, IL, during the years 2003–2012, by integrating statistical techniques with a social network perspective. Unlike previous repeat studies that have been concerned with spatial locations and geographical distances of crime incidents, we will focus on arrestees and relationships among arrestees. Each incident in our dataset includes a unique identification number for each arrestee taking part in a crime incident, the date of the incident and the type of crime. Of particular interest to police is the behavior of violent criminals [4], so we divide our data into two mutually exclusive datasets – one containing only violent crimes and the other containing all other crimes – and we perform analyses on the two datasets separately. We refer to these datasets as the *violent* dataset and the *non-violent* dataset, respectively. The former consists of 6630 arrestees, while the latter consists of 941,029 arrestees.

Through the construction and analysis of social networks and application of statistical techniques, this paper aims to discover patterns by repeat arrestees in Chicago. In Section 1 we use a Poisson model to describe the situation in which events are independent of one another and occur only by chance, referring to this as the null model. We describe and apply our counting technique to test our datasets against the null model, and show that Chicago's exact-repeat incidents are not due to chance alone. We describe the social network in Section 2, where we measure the spread of repeat effects through the network by keeping track of the geodesic distance between incidents – that is, the network separation of the two arrestees – and applying well-established spatiotemporal descriptive statistics. We show that repeat effects in our data diminish with time and geodesic distance. We conclude the paper with a summary and discussion.

2. Exact-repeat effects

If there were no repeat effects, an individual's participation in a crime incident would be statistically independent of participation in other crime incidents. This model is contradictory to the existence of repeat effects and will serve as our null hypothesis. Moreover, an arrestee cannot participate in simultaneous criminal incidents, as such incidents would simply be thought of as a single event. Independence of the incidents implies a Poisson process [21], as reviewed next.