

Near-Repeat Patterns in Philadelphia Shootings

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Research from property crime studies has identified a near-repeat phenomenon, where the risk of repeat burglary victimization is transmitted from a burgled location to nearby locations for a limited amount of time. This article explores the potential for near-repeat patterns to exist in another crime type, specifically the incidence of shootings. Using new tools developed to quantify the spatio-temporal patterns of near-repeats, a study in Philadelphia, U.S.A. finds that there are elevated patterns of near-repeat shootings within 2 weeks and one city block of previous incidents. The elevated risk of a shooting during this period is found to be 33 per cent greater than expected. It is speculated that possible reasons include coercion, retaliation and escalation. Given that the study takes place against the backdrop of a police operation to mitigate retaliatory shootings, the potential for using this information to influence crime prevention policy is discussed. *Security Journal* (2008) 21, 58–76. doi:10.1057/palgrave.sj.8350068

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Introduction

The recent discovery of the near-repeat phenomenon in burglary patterns has highlighted the communicability of crime events that affect the risk level at nearby locations. The near-repeat phenomenon states that if a location is the target of a crime such as burglary, the homes within a relatively short distance have an increased chance of being burgled for a limited number of weeks (Townshley *et al.*, 2003; Bowers and Johnson, 2004; Johnson and Bowers, 2004a, b). This communicability of risk to nearby locations for a short amount of time raises the possibility that other crime types may also suffer from a near-repeat spatio-temporal pattern of behavior. However, it is likely that the underlying theoretical constructs that predict why this might vary considerably from property crime to violent offending.

Availability of a database of shootings in the city of Philadelphia, PA, enables us to examine near-repeat patterns with a type of crime significantly different in offender motivation from burglary, a property offense. In this paper, we begin by exploring the literature of murder, coercion and retaliation as a brutal reality of life on the streets in the poorest communities in America. With that conceptual framework in mind, we then demonstrate that statistical routines developed to explore near-repeat patterns in property crime (see Townshley *et al.*, 2003; Bowers and Johnson, 2004; Johnson and Bowers, 2004a, b) can be applied to violence, and a case study of shootings in Philadelphia clearly demonstrates that near patterns exist. The paper concludes by exploring the applicability of this knowledge to crime prevention.

Nature and extent of murder

In 1974, David Ley wrote a book entitled *The Black Inner City as Frontier Outpost* in which he argued that life in America's inner cities had much in common with the American frontier. He is not alone in this assertion. David Courtwright (1996) pointed out that of the 89,000 miners who arrived in California during the 1849 gold rush, 20 per cent were dead within 6 months, many dying as the result of violence. According to Courtwright (1996), societies with the highest rates of violent crime have populations with an over abundance of young males who are "awash with testosterone" and unrestrained by social controls such as marriage and family, controls that are associated with a decrease in crime, including violence (Sampson *et al.*, 1997).

Courtwright (1996) argued that rising violence rates in American cities during the 1960s and 1970s can be attributed to the fact that men were avoiding, delaying or terminating marriage. In 1960, Americans spent an average of 62 per cent of their lives with spouses and children, an all-time high. By 1980, they spent 43 per cent with families, an all-time low. Both the illegitimacy and divorce rates began to spiral upward resulting in poorly socialized and supervised children. The inner city urban ghetto became the frontier community of today. Although the sex ratio is more balanced than on the American frontier, the presence of unsupervised, poorly socialized males, who have easy access to guns, drugs and vice, have produced a crime rate of similar proportions (Siegel, 2007).

Another similarity between the contemporary inner city and the American frontier at the turn of the last century is the availability of firearms. Around the time of the American Civil War, the Colt manufacturing company began mass production of handguns. Today, relatively cheap handguns are readily available due to woefully lax handgun laws in the United States (Weiner *et al.*, 1990). Jacobs and Wright (1999) illustrate how these handguns are used violently in a contemporary American inner city. They note that the decision to commit an armed robbery stems most directly from a perceived need for fast cash. But this need for fast cash is activated, mediated and shaped by participation in a street culture that has much in common with the life on the American frontier, especially the use of handguns for intimidation and violence.

Finally, the American frontier and our inner cities are similar in the role of formal law enforcement in providing social order. Organized law enforcement on the American frontier was often lacking. Some of the earliest law enforcement officers were little more than hired guns with no formal training in diffusing volatile situations (Weiner *et al.*, 1990). For a different reason, formal law enforcement is not as effective as it could be in our inner cities. The difference is due to the fact that many citizens of inner cities do not rely on formal law enforcement to settle disputes (Anderson, 1999). There are active campaigns working against cooperating with the police exemplified by the "Don't Snitch" tee shirts and rap music that vilifies the police. If one cannot depend on formal law enforcement to handle disputes, the only option available is violence. Anderson (1999) referred to this mentality as the "code of the street."

The "code of the street" actively discourages cooperation with, and respect for, formal law enforcement and encourages the use of violence to solve personal disputes. As stated by

Stewart and Simons (2006, p. 3):

...the economic and social despair of neighborhood disadvantage, persistent poverty, blocked opportunities, racial discrimination, and an overall lack of faith in legal and political officials have created an oppositional culture among street families whose norms are often conducive to violence and are at odds with those of the decent family. Street families are completely immersed in the code of the street and place emphasis on toughness and violence...

The code of the street is summed up nicely in Anderson's (1999) argument that high rates of joblessness, poverty, racial discrimination, alienation, mistrust of the authorities, hopelessness and violence characterize many inner city minority neighborhoods that instill in some (but not all) residents an oppositional culture that rejects mainstream values. The "code of the street" emerges where the influence of the police ends and personal responsibility for one's safety begins.

National statistics bear out some of the above assertions. In 2003, 16,300 people were killed in the U.S. Almost one-quarter of these homicides occurred in cities with populations of more than one million. Of all, 75 per cent of the victims and 90 per cent of the detected offenders were male, and almost 50 per cent of all victims were African Americans. The majority of these murders were committed with a handgun (Siegel, 2007).

The reality is that there are patterns showing a disproportion of violent crime among African Americans. Why the disparity? First, blacks and whites are not randomly distributed spatially across the population. Segregation leads to blacks and whites clustered in separate areas of the city. As Massey and Denton (1993, p. 2) noted, "no group in the history of the United States has ever experienced the sustained high levels of residential segregation imposed on blacks." Furthermore, blacks segregated within inner city poverty areas sometimes (but not always) ascribe to a "code of the street" that does not rely on the criminal or civil justice system to solve disputes (Anderson, 1999; Stewart and Simons, 2006). However, Anderson (1999) differentiated between what he labels "street people" and "decent people." He noted that even in inner city poverty areas, the majority of the residents are decent people who do not ascribe to the code of the street. Furthermore, Baumer (2002) noted that wealthy white residents are also not likely to rely on formal authority to solve their disputes. Rengert *et al.* (2005) found that calls for service were highest in the heart of drug-sales areas of an inner city, an area one would not expect the residents to rely on the police to solve their problems. Although "code of the street" may be part of the explanation, it is not the only explanation for the spatial clustering of violence. In the following section, we examine other possible explanations for one form of violence (shootings) in Philadelphia. We are particularly interested in the extent to which they spatially and temporally cluster in the microenvironment (near-repeat shootings).

Why we expect near-repeat shootings

Nettler (1982) described several "routes" to violence in contemporary society. The first is romantic interchanges. People sometimes resort to violence against a mate they fear they are losing or against the person who is intruding on their romantic turf. Others use guns to commit an armed robbery or other felony. Finally, guns are used to settle disputes in illegal activities such as illegal drug sales where the parties do not have access to criminal or civil

justice systems to settle their disputes. The question is why, in each of these cases, would we expect a repeat shooting within a short distance and shortly afterwards?

In the case of a lover's triangle, a near-repeat shooting (one that occurs shortly after the initial event, and occurs at a nearby location) is likely if the victim is not seriously injured and returns to the home (or other shooting site) to retaliate. If serious injury or death occurs, a friend or relative of the victim may return there to settle the score. Also, a friend or relative is likely to retaliate if the original victim was a woman. Mullins *et al.* (2004) note that the modal reason for retribution offered by the women in their study, whether they were victims or instigators of the retaliatory violence, involved disputes over a man. The women interpreted interference in a romantic episode as disrespectful and saw the need to use payback to restore their reputations.

In the case of a shooting in the act of committing a felony such as an armed robbery, a near-repeat is less likely, unless again, a friend or relative may return to settle a score if the attacker is shot by a store owner. Mullins *et al.* (2004, p. 922) quoted a subject on this issue:

It's all about if you hurt somebody that I love, then I'm gonna hurt somebody you love. If you make my mama cry then, I'm gonna make your mama cry, and this gonna go all back and forth.

Finally, one expects repeat and near-repeat shootings to occur in public or semi-public places that are the focus of routine illegal activities of many potential victims. An excellent example of this is a drug-sales corner. Unable to report a crime to the police, drug dealers have a strong incentive to retaliate. In these communities, police may not even be used to help mediate legal disputes. The reason police are not used to settle legal disputes in some inner city communities is that they are not granted legitimacy by the drug-market participants.

In the case of disputes during illegal activities, retaliation becomes the only way to bring the swiftness, certainty and severity of punishment back into deterrence. Here, a shooting may take place for many reasons (disputes) and leads to retaliation from the victim or his family and friends. Accepting one's victimization is an untenable proposition. To be exploited without fighting back is to be a punk, and to be a punk is to open oneself up to even more exploitation (Jacobs *et al.*, 2000). Just as the drug-sales area attracts drug users, it is also expected to be the hub of violence used to enforce contracts and protect the enterprise (Blumstein, 1995; Rengert, 1996). Although Ousey and Augustine (2001) found in a multi-city analysis that drug-market violence did not impact black youth to the extent it did white youth, in any case violence tends to be exchanged reciprocally (Singer, 1986).

In the examples above, the psychological reason for a near-repeat shooting centers primarily on either retaliation or coercion, and to some degree a third derivative, escalation. Jacobs *et al.* (2000) defined retaliation as an act of harm inflicted on another person in return for being wronged oneself. At its heart, retaliation is a compensatory action designed to correct a perceived inequity. It is the concept of "an eye for an eye": the settling of the score. Coercion involves using violence to enforce agreements and/or to keep someone from interfering with legal or illegal activities. In both of these cases, a shooting may also result from "upping the ante," an escalation where a milder form of intervention was not successful. It can also be the result of increasing the use of force beyond what was experienced to either

send a message to stop or to incapacitate the victim so that they are no longer capable of continuing their activity. On the other hand, lethal violence also raises the odds and possibility of retribution – particularly when drug-selling victims are gang-affiliated (Jacobs *et al.*, 2000) – and so the cycle continues.

Each of these psychological reasons for a shooting would lead one to expect a near-repeat as the previous victim returns to the site of the previous shooting to settle the score. Before continuing, a formal definition of a near-repeat shooting is necessary.

Definition of a near-repeat shooting

There are two aspects to a near-repeat shooting. One is the time dimension and the other is the spatial dimension. To be classified as a near-repeat shooting, the second shooting must occur soon after an original shooting. This is generally defined within a couple of weeks after the original shooting. To be a near-repeat shooting, the second shooting must also be close spatially to the original shooting. In this study, the spatial unit used is the city block, which, in Philadelphia, averages approximately 400 feet in length. Combining these two criteria, we would expect a near-repeat shooting to occur within a week or two and within a city block or two of the previous shooting. However, it cannot be at the same place or time as the original shooting as may result from a shoot-out between two rival gangs. This latter event is a repeat victimization, the subject of which is covered elsewhere in the environmental criminology literature (e.g., Polvi *et al.*, 1991; Farrell and Pease, 1993; Bowers *et al.*, 1998; Townsley *et al.*, 2000; Johnson and Bowers, 2004a).

A formal definition of a repeat shooting is one in which the second shooting happens at exactly the same place as the previous shooting. It also includes shootings that happen as part of the same incident (shoot-out), although they may not be on the same city block. These have different ramifications from near-repeat shootings from a crime prevention perspective and while same-block near-repeats are shown in the results tables (as the same location), they are not considered further in the present study.

The present study applies the near-repeat theoretical framework and software tools (described below) to the instances of shooting in Philadelphia. We selected shooting incidents for this study due to the violent nature of the crime, the importance as an operational priority for police and community prevention efforts, and the potentially different theoretical explanation for near-repeat events, as outlined in the preceding paragraphs.

The following sections describe the data used to examine whether an increase in shootings in the city warranted a “priority corner” operational response from the Philadelphia Police Department. The paper details the analytical technique used, presents the results and concludes by discussing the likely theoretical basis for the findings, and the practical implications for near-repeat patterns in urban shootings.

The study

The following study explores the near-repeat phenomenon in shooting incidents provided to the present researchers by the Philadelphia Police Department. An underlying question that the research aimed to tackle was to see if there was theoretical and empirical support for a

priority-location corner program that sought to deter retribution and retaliation shootings in the immediate aftermath of an incident perceived to be a likely candidate for a repeat or near-repeat incident.

Priority Corners program

A police operation that commenced in Philadelphia in May 2002, called Operation Safe Streets, was successful in driving many drug dealers from street-corner drug markets. The Safe Streets program was designed to limit open-air, street-corner, drug dealing; however, during the program media attention focused on an increase in violence. At the completion of Operation Safe Streets, a program that had been successful in significantly reducing the number of outside drug markets in the city, the operations branch of the police department moved to a more mobile strategy called Priority Corners in order to limit the growth of street-corner violence. Priority corners were determined through an analysis of the likelihood of retaliation or retribution taking place in the immediate vicinity of an initial incident and received additional police attention. An additional component of the program was the intended adoption of the street corner by community groups in order to preempt the return of problems once the police attention had been reduced. This last component of the program is not examined in this paper. The Priority Corners program was not funded to a level to permit city-wide implementation and was simply seen as a stop-gap measure until the city had the resources to invest more effort in a violence-prevention program.

The two questions to be addressed here are: (1) is there statistical and theoretical evidence to support the idea of a Priority Corners program, and (2) did the Priority Corners program have an impact on near-repeat incidents?

Data

Although crime rates in many U.S. cities are dropping, some are seeing an increase in violence. Philadelphia has been wrestling with a gun-violence problem for many years, one that is manifest in a considerable shooting rate, generally in excess of 100 shootings a month, and a homicide rate that usually exceeds one a day. Philadelphia is the fifth largest city in the United States, and is located in Pennsylvania in the northeast of the country between Washington, DC, and New York City. As of 2005, the city population was about 1.47 million, although it sits in the center of a larger metropolitan region of about 6.2 million people. The city's population is about 45 per cent white, 43 per cent black, 4.5 per cent Asian with the small remainder consisting of Pacific Islanders, Native Americans or people of more than one race. About 8.5 per cent of people in the city identify themselves as Hispanic or Latino. Just over 30 per cent of children under the age of 18 years live below the poverty line.

Figure 1 shows 28-day counts of shootings in the City of Philadelphia from 2001 to October 2005. A linear trend line (in gray) shows that the general trend in shooting frequency has been increasing throughout this period. The vertical lines indicate the two 13-month time periods that are employed as the study periods for this analysis.

The data for this study were shootings in Philadelphia, PA, U.S.A. The records consisted of confirmed shootings where a victim was struck (classified as either aggravated assaults or

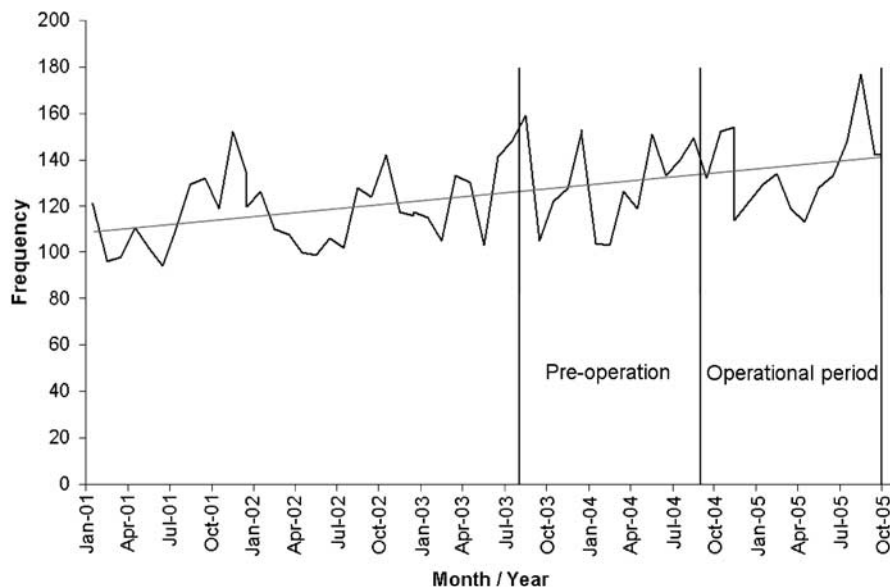


Figure 1. Twenty-eight-day shooting frequencies from January 2001 to October 2005, Philadelphia, PA. Vertical bars indicate study periods in the current study, and the straight (gray) line indicates a linear trend line.

homicides) in the city. The records were gleaned from the record management systems of the police department. A corporal in the Philadelphia Police Department's Research and Planning Unit, based at Police Headquarters, checked the incident database of the department on a daily basis and updated a separate shooting database. This database of confirmed shooting incidents formed the basis for this study. Reports of "shots fired," or the ubiquitous "man with a gun" were not included in the database, although repeat shootings in a single incident were included. Although rare, there were occasional times when there was more than one victim at an incident, and while these data exist in the study database, as explained earlier they were counted collectively in the analysis that follows. This analysis used shootings rather than homicides. Although press reports are more often concerned with the homicide rates in U.S. cities, a more reliable indication of violent crime activity is the number of shootings. While the vast majority of homicides in Philadelphia are as a result of a shooting, the death rate is influenced by the availability of quality medical attention for the victim. Philadelphia does have a number of good hospitals that are conveniently located close to major drug markets and high-crime areas. As a result, the homicide rate is probably lower than that would be expected in other cities, given the prevalence of shootings. The shootings database in effect contained a list of victims of shootings (aggravated assault) and aggravated assault victims who did not recover (homicide) (Harries, 1996).

Although initially outlined by a Headquarters directive in June 2004, the Priority Corners program was in reality widely implemented in September 2004, and 1 September 2004 is the date used as the implementation date for this study. The researchers were able to access 13 months of data after the commencement of the Priority Corners program (1 September 2004–30 September 2005) and so in order to make full use of the available data, these data

Table 1 Sex and race distribution of shooting victims, Philadelphia, August 2003 to September 2005, for time periods before and during the police operation

| | <i>Female (before)</i> | <i>Female (during)</i> | <i>Male (before)</i> | <i>Male (during)</i> |
|----------|------------------------|------------------------|----------------------|----------------------|
| Asian | 7 (4.8%) | 2 (1.5%) | 25 (1.5%) | 25 (1.4%) |
| Black | 110 (75.3%) | 106 (77.9%) | 1442 (84.3%) | 1481 (83.0%) |
| Hispanic | 11 (7.5%) | 2 (1.5%) | 89 (5.2%) | 10 (0.6%) |
| White | 18 (12.3%) | 26 (19.1%) | 155 (9.1%) | 268 (15.0%) |
| Total | 146 | 136 | 1711 | 1784 |

were compared to the 13 months prior to the implementation of the Priority Corners program (1 August 2003–31 August 2004).

The data for the 13 months prior to Priority Corners had four records that the researchers were unable to geocode. Geocoding is the process of assigning geographic location information, usually in the form of *x*- and *y*-coordinates, to address data (Chainey and Ratcliffe, 2005). When they were removed, there were 1,863 shootings in the 13 months prior to priority corners that were available for analysis (a geocoding “hit rate” in excess of 99 per cent). The Priority Corner period had 1,922 records, once five that did not have acceptable location information available, and therefore could not be geocoded, were removed (again, a geocoding hit rate in excess of 99 per cent).

While Philadelphia is a city with a population that is approximately 43 per cent black, it can be seen from Table 1 that the distribution of shooting victims does not reflect this. In keeping with many urban American centers, the racial distribution of shooting victims is skewed heavily toward black males, with over three-quarters of shooting victims falling into this category. Chi-square tests for female shooting victims before and during the Priority Corners program, and for males before and during the police operation, found significant differences in the patterns (female $\chi^2 P=0.017$, male $P<0.001$, $df=3$).¹ For both males and females, the number of Hispanic shooting victims declined during the Priority Corners program, and the number of white victims of both gender increased.

As with race and gender, the age group of shooting victims is also highly skewed, as can be seen in Figure 2, with over half of the victims being in the age group 16–25 years (inclusive, 52.4 per cent). Sixteen shooting victims under the age of 10, and 40 shooting victims over the age of 65 years are not included in Figure 2.

The data that went forward to the analysis stage consisted of three values: the date of the shooting, the *x*-coordinate and *y*-coordinate. Geographic coordinates were recorded in feet so that Manhattan distances could be easily calculated, and were referenced using the standard projected coordinate system for South Pennsylvania (NAD1983 State Plane Pennsylvania South FIPS 3702 Feet). Manhattan distances have been shown to be preferable to direct “crow flies” or Euclidean distances as the Manhattan distance most accurately replicates the actual distance traveled by urban residents to get from point to point without the need for routing measurement software (Chainey and Ratcliffe, 2005). As stated earlier, there were

¹ It should be noted that the expected values for Asian females before and during the Priority Corners program were slightly below the commonly accepted “safe” value of 5.

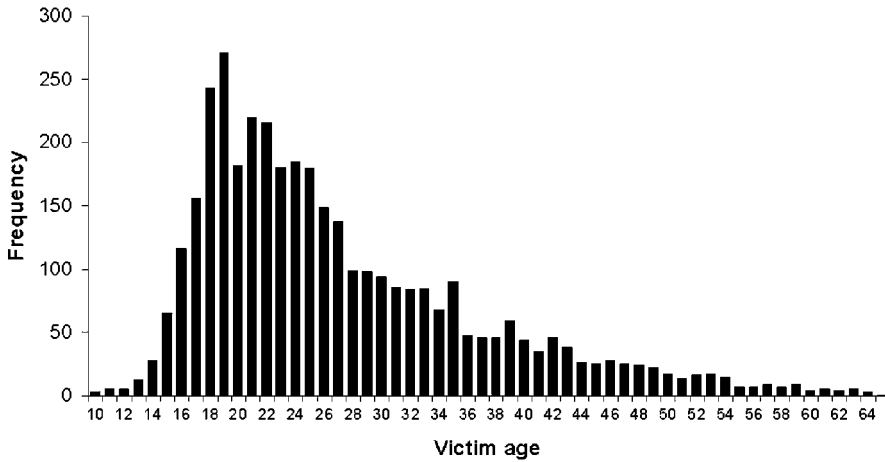


Figure 2. Histogram of shooting victim ages (range 10–65). There were 16 victims under the age of 10 and 40 victims older than 65.

1,863 shootings in the pre-priority corner period, and 1,922 shootings included in the operational period analysis.²

Analysis

The analytical method employed builds on a space–time clustering method first pioneered by Knox (1964) to study the epidemiology of childhood leukemia. The Knox test seeks to determine whether there are more event-pairs observed that occur with a closer proximity in space and time than would be expected on the basis of a random distribution, if the time and place of each event (in our study, a shooting) was completely independent. To do this, each shooting for a particular event-pairs data set is compared with every other, and the spatial and temporal distance between them recorded. The result is a matrix of space–time distances, and these can be aggregated into a contingency table that lists distance bands and temporal bands, such that it is common for columns to record the distances between event-pairs, and rows represent the time between event-pairs. Townsley *et al.* (2003) and Johnson and Bowers (2004a, p. 297) provided examples of contingency tables.

The spatial and temporal aggregation units (known as increments or bandwidths) can be arbitrary, although they should reflect some features of the underlying geography and temporal parameters appropriate for the study. These parameter choices should be considered carefully as they dictate both the parameters for the study and have implications for any practical findings that may help crime prevention practitioners reduce shootings. In this study, we therefore employ a 400-foot bandwidth as being representative of the average length of a Philadelphia city block. Our temporal parameter is a 2-week period. This

² These totals do not exactly match the totals for Table 1 as the police data did not record the gender of six victims before, and two victims after, the police operation.

temporal pattern was chosen after discussion with local police detectives about their experiences of the instances of retaliation or escalation. Although opinions did differ, a number of police officers said that it often took time for the victim to recover in hospital and be discharged before repeat incidents were expected, or it took time for them to recover sufficiently for the victim to convey to relatives or friends the identity of the likely perpetrator. This information was rarely conveyed to police.

Once the contingency table (often termed the Knox table) has been created, the cell counts can be compared against a null-hypothesis situation. One method of determining the likely pattern of event-pairs occurring under a null-hypothesis situation is to calculate an adjusted residual derived from the normal calculation for expected values in a contingency table, based on marginal row and column totals (Townsend *et al.*, 2003). The adjusted residual then identifies those cells with frequencies that are different from expected values. Johnson and Bowers demonstrated a graphical method to show the pattern of adjusted residuals (2004a, p. 249).

The Knox approximation method (as the technique described here is generally termed) does have one potential flaw. Being based, as it is, on an inferential process in the use of marginal totals to derive expected values from the contingency table, it potentially violates the assumption of independence. It is normally expected that event-pairs are independent of other event-pairs; however, in this method a single crime event has a distance/time calculation made to every other crime event in the series. Thus, each crime incident is counted $n - 1$ times in the contingency table.

An alternative to the Knox approximation method (described above) is to take advantage of the greater processing power of modern computers and employ a Monte Carlo approach, and thus circumvent the assumption of independence that causes problems for the Knox approximation method. By computing multiple simulations of the expected values, it is possible to generate an expected distribution under a null hypothesis – using the actual study data. Besag and Diggle (1977) did precisely this in their study, of all things, of the nesting habits of kittiwakes on window ledges of a disused warehouse. The process is a simple one of recomputing the outcome contingency table after randomly permuting the values of the event times, while holding fixed the values of the event location (Diggle *et al.*, 1995).³

In this study, data were analyzed with a Visual Basic.NET program specifically written for the task. The program reads the data and constructs an observed matrix of space–time relationships between shootings. The matrix is aggregated into record counts based on spatial and temporal bandwidths, and the result is a table of observed counts of all shooting pair relationships. The dates are then randomized and the analysis recalculated so that a new matrix can be created, one where the temporal relationships appear as they would under the null-hypothesis conditions, such that in effect there is no spatio-temporal relationship. The resultant matrix and aggregated table of results from the null-hypothesis scenario become an expected matrix and can be compared to see whether the number of observations exceeds the expected for each space- and time-aggregation bandwidth.

³ The approach we describe here has been pioneered by Johnson, Townsend, Bowers and others building on their earlier work in this area (Townsend *et al.*, 2003; Bowers and Johnson, 2004; Johnson and Bowers, 2004a, b) and to be published in forthcoming research findings as the culmination of collaborative work funded by a British Academy International Collaborative Network award.

This process is repeated a number of times, under the regime of a Monte Carlo simulation. The repeated simulations allow researchers to calculate the number of times that the observed (from actual shootings) pattern exceeds the expected number of events for any particular space–time bandwidth. The result is a pseudo P -value. For example, if there are 99 simulations conducted, and the observed number of shooting pairs that occurred in the spatio-temporal bandwidth of 400–800 feet, from 14 days to less than 28 days, exceeds the expected count under conditions of the null hypothesis every time, then the pseudo P -value can be calculated as $P = 1 - n_e / (n_s + 1)$, where n_e is the number of times the expected count was exceeded and is the number of simulations. In the case where the observed count exceeds the expected count on every simulation run of 99 simulations, the pseudo P -value becomes 0.01.

With a temporal pattern determined from police experience, and a spatial bandwidth determined by the size of a city block, 999 simulations were run on each data set (prior to and during the priority-corner operation). Analysis time for a run with 999 simulations and just under 2,000 events was about 45 min.

Results

The pseudo P -value results of the near-repeat analysis for the 13 months prior to the implementation of the priority-corner operation are shown in Table 2. Values with an asterisk indicate values where the pseudo P -value is smaller than 0.05, and the likelihood of this occurring by chance is less than one in 20. As the table shows, there are only a few table cells that have a pseudo P -value less than 0.05; however, a significant value is found in the theoretically expected area of short time periods and short distances, as would be expected if retaliation or escalation was an issue. This area is indicated by the top-left of the table. The marked area indicates where we would theoretically expect to see an increase in shootings, within 14 days and one block (400 feet) of a previous shooting, compared to the pattern observed under the null hypothesis. It would therefore appear that prior to the Priority Cor-

Table 2 Near-repeat analysis pseudo P -values for 13 months prior to the start of the priority-corner operation

| <i>Distance\time</i> | <i>0 to <14</i> | <i>14 to <28</i> | <i>28 to <42</i> | <i>42 to <56</i> | <i>56 or more</i> |
|----------------------|--------------------|---------------------|---------------------|---------------------|--------------------|
| Same location | 0.867 | 1.00 | 1.00 | 1.00 | 1.00 |
| 0 to <400 | 0.043 ^a | 0.497 | 0.394 | 0.585 | 0.884 |
| 400 to <800 | 0.774 | 0.33 | 0.662 | 0.239 | 0.531 |
| 800 to <1200 | 0.969 | 0.814 | 0.94 | 0.912 | 0.001 ^a |
| 1200 to <1600 | 0.107 | 0.226 | 0.619 | 0.769 | 0.747 |
| 1600 to <2000 | 0.712 | 0.002 ^a | 0.998 | 0.371 | 0.562 |
| 2000 to <2400 | 0.856 | 0.998 | 0.548 | 0.507 | 0.013 ^a |
| 2400 to <2800 | 0.871 | 0.966 | 0.771 | 0.361 | 0.034 ^a |
| 2800 to <3200 | 0.736 | 0.482 | 0.028 ^a | 0.142 | 0.898 |
| 3200 to <3600 | 0.318 | 0.546 | 0.283 | 0.789 | 0.535 |
| 3600 to <4000 | 0.048 ^a | 0.821 | 0.954 | 0.881 | 0.146 |
| 4000 or more | 0.998 | 0.122 | 0.042 ^a | 0.232 | 0.498 |

^aIndicates $P < 0.05$.

Table 3 Near-repeat analysis pseudo *P*-values for 13 months after the start of the priority-corner operation

| <i>Distance\time</i> | <i>0 to <14</i> | <i>14 to <28</i> | <i>28 to <42</i> | <i>42 to <56</i> | <i>56 or more</i> |
|----------------------|--------------------|---------------------|---------------------|---------------------|--------------------|
| Same location | 0.999 | 0.999 | 1.00 | 1.00 | 1.00 |
| 0 to <400 | 0.003 ^a | 0.342 | 0.947 | 0.844 | 0.739 |
| 400 to <800 | 0.939 | 0.925 | 0.866 | 0.559 | 0.019 ^a |
| 800 to <1200 | 0.825 | 0.071 | 0.407 | 0.004 ^a | 0.99 |
| 1200 to <1600 | 0.982 | 0.011 ^a | 0.14 | 0.473 | 0.771 |
| 1600 to <2000 | 0.393 | 0.97 | 0.97 | 0.325 | 0.047 ^a |
| 2000 to <2400 | 0.049 ^a | 0.992 | 0.333 | 0.205 | 0.612 |
| 2400 to <2800 | 0.753 | 0.561 | 0.411 | 0.48 | 0.385 |
| 2800 to <3200 | 0.057 | 0.63 | 0.024 ^a | 0.536 | 0.965 |
| 3200 to <3600 | 0.32 | 0.485 | 0.972 | 0.547 | 0.208 |
| 3600 to <4000 | 0.973 | 0.895 | 0.762 | 0.828 | 0.004 ^a |
| 4000 or more | 0.976 | 0.001 ^a | 0.001 ^a | 0.039 ^a | 1.00 |

^aIndicates *P*<0.05.

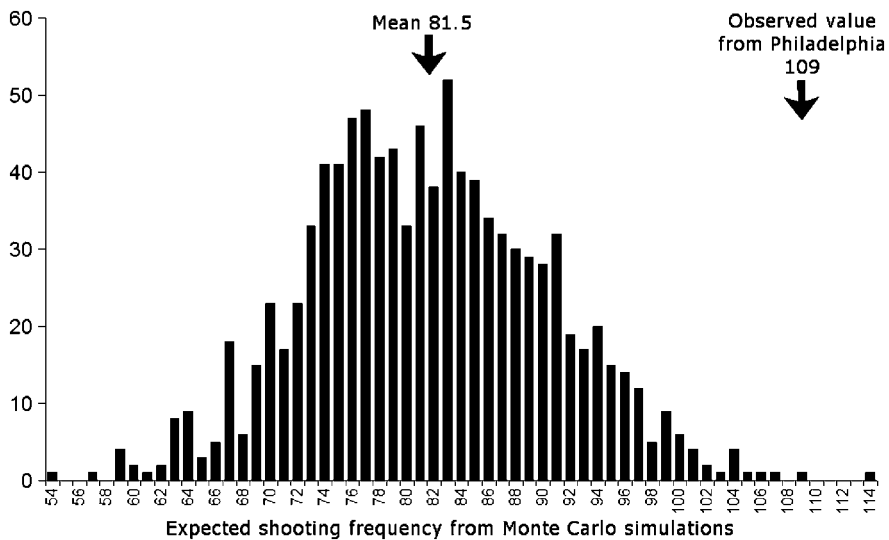


Figure 3. Monte Carlo simulation results from 999 runs examining the expected frequency of shootings in the range 0–14 days, and less than 400 feet from a previous shooting.

ners program, there was a problem of retaliation/escalation, at least within one block and 2 weeks of a prior shooting.

The pattern of shootings from the 13-month period after the start of the Priority Corners program displays a similar statistically significant finding (a pseudo *P*-value of 0.003 based on the Monte Carlo simulation) in the period that represents shootings that occur within 14 days of a previous shooting, and within a one-block distance of 400 feet (Table 3). This

finding suggests that the likelihood of a near-repeat shooting remained the same during the priority-corner period.

Figure 3 shows a subset of the results from the 999 simulation run for the 13 months of shootings after the police operation began. The graph shows the expected frequency of shootings expected in the 0–400 feet spatial range, and within 14 days of a previous shooting. As the simulation shows, the expected value under a null hypothesis of a random distribution of shootings is about 81 shootings (specifically the 999 values have a mean of 81.5 with a standard deviation of 8.3). The first arrow indicates this mean, while the second arrow shows where the actual observed value of 109 sits. From this, we can calculate that the actual number of shootings in the period under examination is approximately 33 per cent greater than would be expected under a random distribution hypothesis (interpolated from the mean).

From an operational perspective, it is possible to identify areas for crime prevention activity. For example, there may be value for police commanders to identify potential patterns

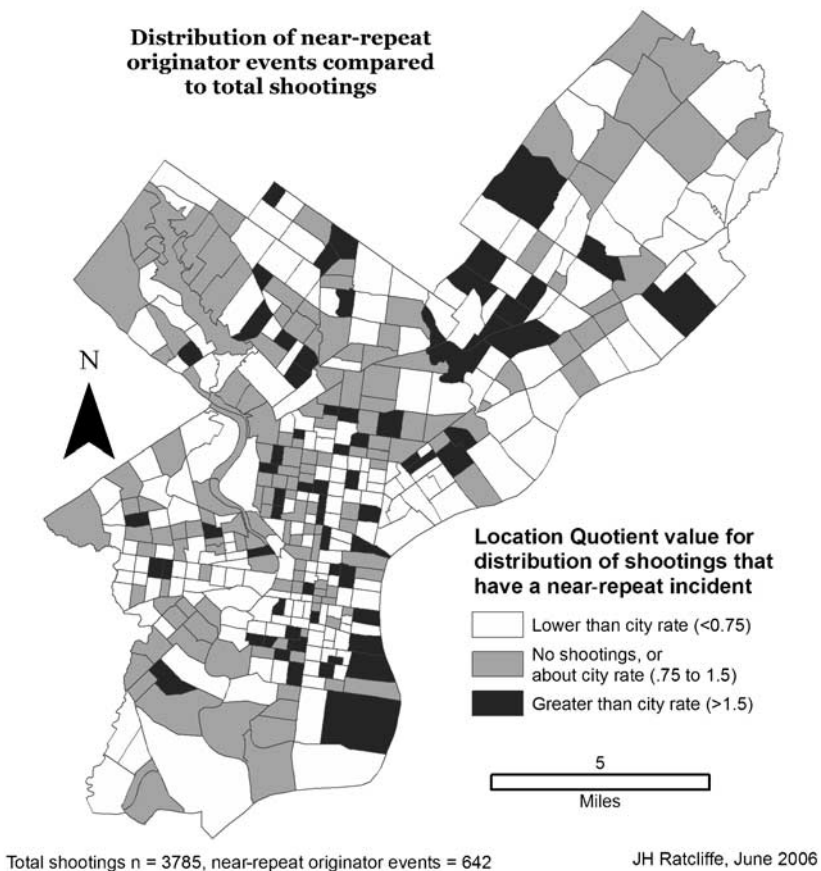


Figure 4. Location quotients for near-repeat initiator events.

in, what we term here, “initiator events”: those shootings that are the first event in one or more near-repeat pairs. If it is possible to identify patterns in these initiating events, it may be possible to more precisely target activities such as the Priority Corners program. Figure 4 shows location quotient patterns for the distribution of initiator events compared to the general distribution of shootings across the city for the 26-month period. Location quotients are values that indicate the relative distribution of a feature compared to the expected distribution if that feature were distributed evenly across the whole region. In this case, the figure shows police sectors and the relative distribution of initiator events compared to all shootings. With a total of 642 initiator shootings from a total of 3,785, we would expect 17 per cent of the shootings in each sector to be initiator events. In Figure 4, the gray sectors indicate areas that either had no shootings, or had a rate of initiators-to-all shootings that was around the city rate of 17 per cent. The white areas indicate areas that have fewer than expected initiators, and the dark regions indicate areas that have an over-distribution of initiator events – areas where a Priority Corners program could have greater chance of success. Interestingly, the distribution of initiator events is not concentrated in areas with the majority of shootings, as the correlation between sector values for location quotient and shooting frequency is only 0.296. Near-repeat initiators were therefore operating under a different spatial regime than the general shooting pattern.

Discussion

The results show that, even with the Priority Corners program in operation, the risk of a repeat shooting within two weeks and one block of a previous event was elevated 33 per cent over the normal background risk of a shooting. Our analysis of shootings over a 26-month period finds evidence of a sustained problem of near-repeat shootings. Although the phenomenon is similar in statistical composition to patterns of near-repeats found in burglaries, and can be detected with similar tools, the cause of this pattern of criminality is considerably different. This section discusses some potential explanations for the patterns seen. There are two issues to consider: (1) the general cause for a spike in near-repeat shootings and (2) the reason that the Priority Corners program was not able to reduce the near-repeat pattern to a statistically significant level.

Given the literature (described earlier in the article) that finds a section of the public are driven by a need to be seen to be strong, not to show weakness and to face threat with threat, it is not surprising that a shooting increases the likelihood of another in the vicinity within a week or two. Our research is unlikely to come as any surprise to police officers from big cities, nor to homicide researchers. Where this article makes a contribution is in the use of a statistical technique to both quantify the problem and as a potential evaluation mechanism for near-repeat prevention tactics. In many deprived urban neighborhoods, the incentives to maintain a violent lifestyle are strong, and so attempts to prevent near-repeat shootings would have to either address the incentives that drive the violence in the first place, or manipulate situational factors to increase the risk or effort to engage in gun violence. The incentives include a need to show strength in the face of a challenge or threat, and to respond to any potential assaults, and crime reduction programs such as proactive police patrols focused on firearm recovery (Sherman *et al.*, 1995) or broader attempts to limit gun ownership may act to increase the risk or effort.

Under these circumstances, the ability of a short-term police action to address these issues is limited. The police Priority Corners program in Philadelphia appeared to have had two main aims. The first was to reassure the public that police were responsive to violent incidents, and the second was to try and limit the number of near-repeat incidents in the vicinity of the source incident. In the first aim, media and community feedback suggests that the police were successful in appearing responsive to the increase in violence in the city.

The second objective was always going to be more difficult to achieve given budgetary constraints on the police department in the face of an increase in violence. The increase in violence had the effect of increasing the number of corners that required attention, while the budgetary constraints reduced the number of corners that could be tackled. In the end, the police commanders were left in an unenviable situation. Given the high number of shootings in general, the actual observed number of shooting pairs that occurred within two blocks of each other and within two weeks of each other was 315 in the 13 months since the inception of the priority-corner operation. This translates to only 157 potentially preventable shootings (the temporally second event in the shooting pair), if a preventable shooting occurs within two blocks and two weeks of a prior incident. This figure should be considered in the light of the nearly 2,000 shootings in the city during the study period. Such a small potentially preventable number leaves police running around to try and prevent a limited number of near-repeat incidents when faced with over 100 per month to choose from. Although the police department were circumspect in their decision to implement a priority corner (by using investigative information to try and identify the locations most likely to result in a repeat shooting), deciding where to allocate police resources and effort under these circumstances is very difficult. To use a medical analogy, even if the program was successful in theory, and this research lends tacit support to that notion, the dosage was too low.

While unlikely, it is possible that the increase in shootings is the result of an unintended consequence of police action. It is known that a number of well-meaning crime prevention strategies have had deleterious consequences that were unforeseen by the practitioners (Grabosky, 1995, 1996). It is a possibility that the introduction of a sustained police presence in the aftermath of a shooting had the negative impact of heightening tension in the area, drawing unwanted attention to the locale. As a result, this might have actually inflamed local tensions resulting in a continued likelihood of another shooting. Any increased stress in a few high-crime neighborhoods as a result of police attention might have resulted in sufficient retaliatory shootings that any potential benefit from the program in other parts of the city were essentially countered by an increased risk of a near-repeat in other areas. However, this outcome is probably unlikely because an overstretched and under-resourced police department is not likely to feature prominently in the sub-cultural machinations of local block politics within the criminal underworld.

A more likely reason for the lack of success in limiting near-repeat shootings was the difficulty in preventing retaliatory shootings in neighborhoods where there is little cooperation with police. Furthermore, our contacts within the police department feel that the community adoption of corners (a part of the Priority Corners program not evaluated in this paper) never took place in areas with a poor track record of police cooperation, and so the preventive work of the police was not sustained by any community attempts to maintain surveillance of problem corners. Part of the aim of the program was to reduce the likelihood of a repeat shooting in an area long enough for detectives to make inquiries, interview

potential witnesses and the survivor (if the victim has survived) and make arrests. If there is little enthusiasm for cooperation with police then this tactic is unlikely to succeed and the code of the streets is likely to be a more realistic outcome, one that sees the presence of police as an almost neutral inconvenience, but not a significant hindrance.

This last point leads to the issue of crackdown decay (Sherman, 1990). It is certainly possible that an operational tactic, mandated from headquarters, is not as effectively enforced at the street level as one might hope. There are competing demands placed on local police, often seen during the CompStat meeting run by the Philadelphia Police Department for each district once a month. The competing resource demands placed considerable pressure on local district captains in the city. Although shootings and their prevention are a priority, district captains are also liable to answer questions in CompStat meetings regarding drugs, burglary, aggravated assault, robbery and vehicle theft (for further details of CompStat, see Walsh 2001; McDonald, 2002; Firman, 2003; Moore, 2003; Moore and Braga, 2003).

In terms of police tactics, it should be recognized that policing does not occur in a vacuum. The priority-corner approach was not implemented into a policing environment where shootings had been previously ignored. On the contrary, a variety of programs were previously operating, including Operation Safe Streets. Operation Safe Streets identified 300 drug-dealing corners of the city and placed a police officer on permanent duty at that corner. While Safe Streets was ostensibly a program designed to reduce street-level drug dealing in Philadelphia, it evolved during the operation to also focus on gun-violence prevention. In this respect, Safe Streets can be seen as a precursor to the priority-corner style of operation. While Safe Streets had limited success in reducing crime in the immediate vicinity of the operational street corners (see Lawton *et al.*, 2005 for an evaluation of Safe Streets), there were significant financial burdens on the police department as a result. From this, the concept of priority corners evolved as a way to refocus police activity to corners that had gun-violence problems while trying to keep the police department within their operating budget. It is apparent that the resources available to Operation Safe Streets were not available in the later operation. As a result it is possible that Operation Safe Streets, taking place as it did prior to the priority-corner operation, was more effective in reducing street-corner retaliatory gun violence, but perhaps only due to the massive resource implications.

There are also issues of gun violence that are not related to policing. The general increase in gun violence as seen in Figure 1 may be related to the lack of neighborhood cohesion, the drug trade at a local, regional or national level, or other variables that might be far beyond the control of local police. As a result it should be recognized that the general increase in shootings seen in Figure 1, as well as the nature of the near-repeat phenomenon, may be unrelated to factors that the Priority Corners program could be expected to influence. In other words, it is possible that the nature of shootings in Philadelphia might have changed over time, and it is unrealistic to expect a program that was introduced as a more financially viable stop-gap to Operation Safe Streets would be very effective. Interestingly, the pattern of victim characteristics did change from the pre-operation period to the operational time. As Table 1 shows, there was a reduction in Hispanic victims and an increase in white shooting victims during the Priority Corners program, though it is unclear why this might be.

While there are certainly findings here that suggest that the police operation was not effective in preventing immediate spatio-temporal shooting incidents (except perhaps among Hispanic victims), there may be positive benefits from the operation from the police

perspective. Importantly, it should be stressed that the motivations behind the police operation have been shown here to have strong theoretical and empirical support. Attending to priority corners appears to be operationally sound, at least in terms of preventing immediate retaliation. The lack of reduction in city-wide near-repeat shootings is most likely to be more of an issue with dosage of police available to corners rather than a fault with the operational strategy. It is certainly possible that police did prevent near-repeat shootings at patrolled corners: there were just too many corners and too few police. Future work that is able to find spatial or socio-economic correlations to near-repeat shooting locations may be of substantial value.

The immediacy of the police response may have signaled to the local community that the police were trying to do something about the shooting problem and were responding quickly. This program may have at least provided some reassurance to the community, one mechanism by which police can reduce fear of crime. Given that the public are not well versed in the effectiveness of police crime-control tactics, the priority-corner approach would at least have demonstrated that police were “doing something” about a recent shooting incident. Finally, while the tactic has apparently been, on the evidence presented here, unsuccessful in stemming the flow of near-repeat incidents, it does at least show that police are moving away from a reliance on random patrol and rearranging some operational patterns to be more information-led. Although this at first seems to be a reactive strategy, it is proactive in desire, seeking to reduce the likelihood of a future incident.

Conclusion

Much of the evidence for retaliatory shootings has come from anecdotal accounts of individual cases. Evidence of a larger problem has been harder to confirm. This article shows that there is quantitative evidence of a pattern of near-repeat shootings taking place within the distance of one block from a previous incident within a period of 14 days, even when excluding multiple incidents that happen at the same time and place. The probability of this observed pattern occurring by chance was less than one in twenty ($P < 0.05$), and the increase in likelihood (based on the mean expected rate) suggests an increased risk of about 33 per cent. This is, to the best of the authors' knowledge, the first quantitative evidence to support what many cops know or believe, that there is a sustained near-repeat problem with shootings at the city level.

This paper also presents evidence that the near-repeat phenomenon, first discovered for property offenses, can exist for non-property crime. In the case of property offenses, and especially domestic burglary, there are sound theoretical reasons for the prevalence of the near-repeat phenomenon, reasons grounded in environmental criminology and the literature of offender decision-making. In the case of shootings, the reasons are more likely related to issues of retaliation, escalation or coercion. Although a number of near-repeats may not be connected to the linked incidents, the strength of the pattern in Philadelphia is significant, suggesting a more sustained problem in the immediate aftermath of incidents. As a reviewer of this article pointed out, it is possible that many of the near-repeat shootings are in fact complex events where an understanding of the combined chain of events leading from one shooting to another is necessary in order to consider any preventative measures.

The police department responded to an increase in shootings during the summer of 2005 (the highest peak in the graph at Figure 1) by promoting a homicide captain to Deputy Commissioner for Violence and Crime Control. The Priority Corners program preempted this move, but was always seen as a stop-gap measure in anticipation of a more focused and concentrated anti-violence effort (Deputy Commissioner Patricia Giorgio-Fox, personal communication). With limitations on overtime and resources, the city was unable to put sufficient resources into the Priority Corners program to respond with sufficient numbers to every incident, and were left in the unenviable position of having to limit the number of corners chosen for attention. The stop-gap measure of the Priority Corners program has now been superseded by a new program. Given the range of tactical options, such as replication of the Kansas City Gun Experiment, Project Exile or the Boston Gun Project, there would certainly appear to be a range of possible tactics, and no shortage of shootings to apply them to.

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