MICRO-LEVEL SPATIO-TEMPORAL RELATIONSHIPS BETWEEN FIREARM ARRESTS AND SHOOTINGS IN PHILADELPHIA: IMPLICATIONS FOR UNDERSTANDING OF CRIME, TIME, PLACE, AND POLICING

A Dissertation
Submitted to
the Temple University Graduate Board

In Partial Fulfillment
of the Requirements for the Degree
DOCTOR OF PHILOSOPHY

By
Brian R. Wyant
August, 2010

Examining Committee Members:

Ralph B. Taylor, PhD, Advisory Chair, Department of Criminal Justice
Jerry H. Ratcliffe, PhD, Department of Criminal Justice
Jennifer Wood, PhD, Department of Criminal Justice
John M. MacDonald, PhD, University of Pennsylvania

ABSTRACT

MICRO-LEVEL SPATIO-TEMPORAL RELATIONSHIPS BETWEEN FIREARM ARRESTS AND SHOOTINGS IN PHILADELPHIA: IMPLICATIONS FOR UNDERSTANDING OF CRIME, TIME, PLACE, AND POLICING

Brian R. Wyant
Doctor of Philosophy
Temple University, 2010
Doctoral Advisory Committee Chair: Ralph B. Taylor, PhD

The current study examines the relationship between shootings and police firearm arrests at a more detailed spatial and temporal level than has previous work. Using data from Philadelphia during the years 2004 to 2007 two dynamics are investigated: the relationship between a shooting and subsequent police firearm arrests nearby in space and time; and the relationship between a police firearm arrest and subsequent shootings nearby in space and time. In order to simultaneously consider spatial and temporal variation at a more micro-level, the current study uses a modified version of the Knox (1964) close pair method, a spatio-temporal clustering technique first used to study contagious diseases, and later used to analyze near-repeat patterns in the study of crime.

The first question explored the relationship between a shooting and subsequent police firearm arrests. Results showed elevated patterns of firearm arrests were approximately two and a half times greater than would be expected levels of firearm arrests than if shootings and subsequent firearm arrests lacked a spatio-temporal association. Greater than expected elevated patterns persisted for up to about a fifth of a mile away and about one week but the strength of these associations waned. The observed patterns suggest an immediate and geographically targeted police response to a shooting and a somewhat sustained effort. Turning attention to the next question, an

initial slightly elevated level of shootings followed a firearm arrest but for only a couple of days and about one block; shooting swiftly dropped below expected levels as one moves away in time and space. The waning and eventual significant drop in shootings may arise from ecological deterrence, but any suppression of shootings was short-lived.

Overall, the current work highlights the close associations in space and time between police and offenders and suggests that police and offender activity is not simultaneous as the police response to a shooting immediately whereas potential offender’s response to police actions is moderately delayed. Potential implications for theory and policy regarding both police behavior/police organizational responsiveness and ecological deterrence are discussed.

ACKNOWLEDGMENTS

There are a number of people who helped me in a variety of ways to complete this dissertation. First and foremost, I want to acknowledge and thank Dr. Ralph B. Taylor. Dr. Taylor has been a supportive mentor to me since my first day at Temple University. Always extremely generous with his time Dr. Taylor has helped me considerably with the conceptualizing and writing (and rewriting) of my dissertation as well as assisting me on a number of other projects. The feedback is not only vast but also painstakingly detailed. I am most thankful for his patience, thoughtfulness and expert guidance. Dr. Taylor is clearly a top-notch researcher but he is also one of the finest people I have ever had the pleasure to know.

Next, I want to thank Dr. Jerry H. Ratcliffe who ignited much of my interest in the topics explored and method used in my dissertation. Dr. Ratcliffe also constantly reminds me to bridge the gap between practitioners and academics in my research and his presence on my committee ensures my defense and future presentations will be of the highest quality.

Thank you Dr. Jennifer Wood. Among many contributions Dr. Wood helped "pull the project out of the weeds" by asking a simple question "what would a police chief take away from this paper?" I am not sure I always achieved this in my writing, but I will keep her question in mind throughout my career. Overall, I was fortunate to have hit something akin to the dissertation committee lottery. Not only did my three committee members provide fast and insightful feedback, their good humor and encouragement made a long and difficult process much more bearable.

I am also grateful to Dr. Peter Jones who provided opportunities for collaboration and to the rest of the Criminal Justice faculty at Temple University whose doors were always open and who took an active interest in my education and research.

I owe a special debt to Evan Benshetler for his help immersing me in the world of computer programming. I would also like to thank the Philadelphia Police Department and the Philadelphia Adult Probation and Parole Department (especially Dr. Ellen Kurtz) for their time and willingness to share data.

I am grateful for the support and friendship provided by fellow doctoral students at Temple. In particular I thank Brian Lockwood, Chris Kelly, Eric McCord, Chris Salvatore, Scott Hoke, Jaime Henderson, Marie Garcia, and especially Travis Taniguchi who may have graduated even earlier if he had not helped me for so many hours.

I want to thank my parents, Judy and Dennis Wyant for their unwavering support and for instilling in me a tireless work ethic; there could be no better role models. I would also like to thank Iva Hodge for being the best Grandma anyone could ask for.

My daughter Maeve, there has never been a better motivator to finish my dissertation than your impending due date. Toward the end of this process you were my inspiration to write when I did not want to and I could not be prouder you were part of this.

Finally, no one might be happier that I finished my dissertation than my wife Alison; I owe her the greatest debt. Her patience, love, and sacrifice not only helped me through graduate school but having her in my life has made me a better person. Quite simply, without Alison's care and support (and editing) I might never have finished this dissertation, nor would it have been nearly as worthwhile.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1:

INTRODUCTION

Research focus

This study examines micro-level spatio-temporal links between shootings and police arrests for illegal possession of a firearm between 2004 and 2007 in Philadelphia. For the purposes of this research micro-level spatio-temporal means small scale or fine-grained associations in space and time. Broadly speaking, much is known about the relationship between these two types of events. Previous work, however, has not yet explored the spatio-temporal relationships between these two types of events using a micro-level analysis. Such an analysis is conducted here.

Two questions guide the exploration of possible spatio-temporal relationships between shootings and firearm arrests. 1) Are shootings associated with more nearby firearm arrests in the period immediately following compared to what would be expected if the events are not related in space and time? 2) Are firearm arrests associated with fewer or decreasing nearby shootings in the period immediately following compared to a null hypothesis of no spatio-temporal association between the events?

Philadelphia has been especially hard hit by shootings, consistently ranked as one of the most dangerous cities in the United States (Maykuth, 2007). Since the year 2000, Philadelphia has averaged over 100 shootings per month (Ratcliffe & Rengert, 2008) and over 300 homicides per year. About three-quarters of Philadelphia homicides involve firearms (Moore, 2005). Recently the number of homicides has declined since peaking in 2006 with 406. After a slight drop in homicides to 392 in 2007, homicides fell considerably to 333 in 2008 and 305 in 2009 (Pennsylvania State Police, 2010).

Research has found various links among police arrests for illegally carried firearms and shootings. At least two distinct perspectives have informed this work.

The first perspective focuses on organizational responsiveness. Some research has argued that instead of arrests suppressing later crime, higher arrests indicate an informed police response to earlier changes in crime (Decker & Kohfeld, 1985; Jacob & Rich, 1980; Kohfeld, 1983; Kohfeld & Sprague, 1990). Police administrators reacting to shootings can allocate more officers to the troubled locations and/or increase pedestrian and vehicle stops. The shifting of police tactics might produce more illegal firearms detected by police and therefore more arrests for illegal firearm carrying. If these dynamics apply here, areas that experience a shooting, or locations nearby, might experience more arrests for firearm violations soon thereafter.

The current study, although it will not test a causal model of police responsiveness, will generate information about the contours of police responsiveness, as seen through firearm arrests: is it immediate and spatially targeted vs. immediate and spatially diffuse vs. lagged and spatially targeted vs. lagged and spatially diffuse? These patterns may relate to actual police dynamics such as police recognizing changes in offending on their own, or from temporally lagged directives from supervisors, or from a combination of the two.

The second perspective relies on ecological deterrence and incapacitation frameworks. Reducing the number of illegally carried firearms via arrests and threats of arrest appears to result in fewer shootings, although important questions about this line of work remain (Cohen & Ludwig, 2003; McGarrell, Chermak, Weiss, & Wilson, 2001; Moore, 1980; Sherman & Rogan, 1995; Villaveces et al., 2000). Emphasizing the enforcement of laws forbidding carrying concealed weapons without a permit by increasing the number of firearms police seize could have two effects. It should not only temporarily incapacitate those who may criminally use a firearm, but also has the potential to act as a deterrent to those illegally carrying a firearm or considering doing so. The latter effect may work through either an increased police presence and/or the spread of information about arrests. If arresting people for illegally carrying firearms reduces shootings and that link depends not only on incapacitation but also general deterrence processes, and the latter are somewhat place-dependent, then shootings should decline in locations near where there has been at least one arrest for illegally carrying firearms for at least a short time after the arrest.

Although the current research does not directly test whether incapacitation and/or deterrence effects are producing fewer shootings, the general spatio-temporal patterns observed might reflect and help us better understand dynamics related to incapacitation effects or the spread of information about police activity. Both of these foundational ideas are thought key to ecological deterrence, which in turn is thought to generate reductions in shootings.

Alternatively, the patterns observed might not reflect any foundational ideas thought key to ecological deterrence, because the investigation is being carried out using a much finer grained analysis than has been used in any of the previous relevant works. The current investigation therefore might suggest different dynamics.

Generally then, the micro-level spatio-temporal links examined here could illustrate some theoretical dynamics previously thought relevant to understanding the impacts of shootings on police responsiveness, or the impacts of firearm arrests on later shootings; or, they could suggest some relatively new dynamics not previously envisioned by either models of police responsiveness or ecological deterrence. Berk and MacDonald (2009) have noted “crime can vary at more micro levels in interesting and important ways” and capturing fine-grained spatial and temporal variation in crime may “ultimately contribute to theory development” (972). In short, because the current investigation is much more finely grained than previous works, it is not testing one particular theory; further, it is not clear if the patterns observed will prove relevant to previously postulated theoretical dynamics, or if new dynamics will be suggested.

Findings may have implications for both theory and practice. Theoretically, the resulting spatio-temporal patterns observed may have implications for police organizational responsiveness to crime, ecological deterrence, or an alternate view. Examining these spatio-temporal links in a more detailed manner permits gauging if the links align with corresponding suggested police and offender dynamics. Considering practice, findings from the first question may clarify contours of police responsiveness to shootings in space and time. This could be useful for police as they consider how to allocate scarce resources and officers’ effort. Additionally, findings from the second question may add valuable information about police efforts to discourage illegal firearm carrying in public places as a means to reduce shootings.

Gaps in knowledge and analytic method

The previous arguments highlight that arrests for illegal firearm possession and shootings can be theoretically linked and likely occur close to each other in space and time. A principal issue for research on the effects of crime on arrests, and of arrest on crimes across geographic territories (i.e., ecological or structural deterrence), is identifying the most valid and/or reliable units of spatial and temporal aggregation (Cousineau, 1973; Kane, 2006). Research on and theories about these links might benefit from using finer spatial and temporal units. Covariation patterns depend, sometimes substantially, on units of spatial and temporal aggregation used (Hannan, 1971). The current study attempts to overcome three main challenges to creating units of spatial and temporal aggregation.

First, previous work has used spatial units such as states, cities, census tracts, or patrol beats that may not have captured important area dynamics influencing offender and police behaviors. Underlying social, demographic or organizational geographies will likely shape, among other things, criminal opportunities, the rate at which police react to crime, the social networks that may communicate information about police activity to criminals, and the spread of information about the proliferation of illegal firearm carrying. Large spatial units might not identify or might conflate relevant spatial disparities affecting illegally carried firearms, police arrests for illegally carried firearms, and shootings occurring within these spatial units. Further, even smaller spatial units developed to portray homogeneous populations may still not capture the spatial variation influencing offender and police behaviors; these dynamics may connect across the spatial units used because events in one unit may be influenced by dynamics in nearby but separate spatial units. Unfortunately, the appropriate level of spatial aggregation to measure dynamics related to offender and police behavior around shootings is not known. Multiple dynamics might be operating at different levels.

Second, in a similar vein but temporally, data analyzed yearly, quarterly, or monthly may obscure key features of links between police arrests for illegally carried firearms and shootings. Focusing on the second question, potentially, offenders might learn quickly about how police have responded to a shooting; this could swiftly alter offenders' perceived risks of apprehension in some locations. If offenders learn quickly about what police are doing differently, then using longer temporal units of aggregation in research may obscure such dynamics. Alternatively, if the temporal units used are too short, there might not be enough time for the responsiveness of offenders to emerge in the data. Cusson (1993: 59) argued that research to date on deterrence and perceptions of punishment have not been "time-specific enough." It is not clear yet what temporal units best capture the underlying dynamics thought to be creating these links.

The use of multiple spatial and temporal increments may provide a sensitivity analysis of the hypothesized associations among illegally carried firearms, police arrests for illegally carried firearms, and shootings. Dynamics suggested by earlier researchers should be more or less apparent, depending on the spatial scales and temporal lags specified. If this expectation is supported, it sharpens our understanding of these dynamics and clarifies existing theory. In addition, using these varied spatial and temporal increments may illuminate additional dynamics, which may operate at different and possibly overlapping levels of space and time.

Third, in addition to a lack of clarity regarding appropriate levels of spatial and temporal aggregation, any spatial aggregation process must consider the modifiable areal unit problem (MAUP) and the closely related issue of edge effects. The MAUP arises when areal data are assigned to artificial boundaries generating artificial spatial patterns (Openshaw, 1984). A researcher studying some type of crime incidents across space must decide within those boundaries how to aggregate the data; however, these units may be arbitrary in nature, and even if they are purposefully designed, different areal units will result in different graphic results (Ratcliffe & McCullagh, 1999). Closely related to the MAUP and especially relevant to the study of whether shootings and police arrests for illegally carried firearms are connected is the problem of edge effects of bounded space. Crime incidents and their antecedents may extend beyond the established boundaries of the data available to researchers. This is especially true as the spatial units used for analysis get smaller. Data analyzed within artificial boundaries do not take into consideration the proximity of events to the established boundaries (Rengert & Lockwood, 2008). The use of artificial boundaries of any size (e.g., census blocks, census tracts, counties, cities) will result in the exclusion of events close to the edge but outside a geographic boundary. Phenomena occurring outside a boundary may be excluded, and estimates close to the edge of the boundary may be statistically biased (Rengert & Lockwood, 2008). If a shooting occurs in one spatial unit but an arrest occurs just outside that unit, then that shooting and arrest may not be considered spatially linked when perhaps they are. Based on the configuration of the boundaries of a study, shootings and arrests could be viewed as being in the same or different geographic units.

With this in mind, the use of an event-centered conception of location is used. Instead of aggregating shootings and arrests within spatial units, each event's location is the center of the spatial unit. Concentric circles of varying sizes (e.g., 400 feet radius, 800 feet radius, etc.) are applied around the event. Using an event-centered conception of location, and allowing the events and the corresponding buffers around each event to serve as the spatial units, provides the opportunity to explore the extent to which there are relationships at various possible distances from the events themselves. The event-centered conception of location moves away from simply using the readily available geographic units and decreases potential edge effect problems.

A comparable sensitivity is brought to thinking about how to model time. Instead of analyzing and comparing changes in yearly, quarterly, or monthly aggregate data, the current method allows for the measurement, comparison, and analyses of individual incidents over researcher-specified periods. Calculating the spatial lags and temporal distances between later shootings and prior arrests, and calculating the reverse lags and distances – later arrests and prior shootings – avoids excluding an event because it is outside a somewhat artificially defined geographic region or temporal period.

The use of smaller and varying spatio-temporal units, and the event-centered conception of location should provide a better gauge of appropriate temporal and spatial parameters. Parameters of interest are ones that bound the plausible underlying dynamics that influence police and offender communication and activities -- dynamics affecting both the ability of police to share and react to information regarding shootings that may influence offender and police behavior, and the communication of information about police activity assumed to trigger the processes of deterrence. The current research should not only aid in identifying if shootings and arrests for illegally carrying firearms are related, but also the strengths and scale of those associations.

Although crime incidents may be concentrated in certain places, empirically demonstrating that these incidents are *causally* linked can be challenging. Simply because one finds, for example, that arrests for illegal firearm carrying and shootings occur close together, does not necessarily demonstrate they are causally linked. In fact, one may expect to find an excess of shootings and arrests in some high crime areas. In addition to spatial spuriousness, there also can be temporal spuriousness.

Determining if two or more seemingly separate events are in fact associated is not new in the study of crime. Since at least the mid-nineteenth century it has been recognized that that crime is not randomly distributed (Guerry, 1833; Quetelet, 1842) and that victimization tends to be concentrated on particular people and in certain areas (Chainey & Ratcliffe, 2005). In the last 30 years, attention has turned to the notion that earlier criminal victimization increases the future likelihood of victimization (Sparks, 1981). Later termed repeat victimization, Polvi, Looman, Humphries, and Pease (1991) found that homes burglarized were often re-burglarized within a month. Other offenses have displayed a similar pattern (see Farrell, 1995). Overall, work in the area of repeat victimization has drawn attention to the possibility that one crime or victimization incident may increase the odds of one or more later crime or victimization incidents. Unlike temporal patterns of unrelated crimes occurring at irregular intervals, repeat victimization is characterized by a strong temporal clustering of repeats occurring almost immediately following initial victimization. The clustering suggests that the two (or more) criminal events may be causally linked (Bottoms & Costello, 2008).

More recently, research has focused not only on repeat victimization but also on the greater probability of future victimization for places near an initial crime event; this is termed near-repeat victimization (Townsley, Homel, & Chaseling, 2003). Whereas repeat victimization focuses on the increased future vulnerability that a particular victimized person or place has for another victimization incident of the same type within a specific period (Weisel, 2005), near-repeat victimization highlights increased victimization probabilities of places nearby, for the same type of crime incident during a limited time window soon after the initial crime incident. In a near-repeat framework, after an apartment is burglarized, for a short time after the original event other apartments close by have a higher risk of being burglarized (Bowers & Johnson, 2004; Johnson & Bowers, 2004a). Research on property crimes such as residential burglaries and on violent crimes such as shooting incidents has demonstrated near-repeat patterns (Ratcliffe & Rengert, 2008; Townsley, Homel, & Chaseling, 2003).

Although the recognition of repeat and near-repeat victimization has been both an important theoretical discovery and a tool to concentrate police resources so as to achieve reductions in crime, Townsley, Homel, and Chaseling (2003: 616) pointed out that studying repeat victimization may be complicated by “other features of victimization patterns.” For example, Townsley Homel, and Chaseling (2000) found that burglary “hotspots” may or may not prove stable over time. The authors concluded the unstable hotspots resulted from repeat victimizations while stable hotspots arose from lasting features of the surrounding socio-demographic and physical environment (Townsley Homel, & Chaseling, 2000).

Research has examined if past burglaries increase probabilities of later burglaries nearby (Townsley, Homel, & Chaseling, 2003) or if past shootings increase chances of future shootings nearby (Ratcliffe & Rengert, 2008). More recently, one study to date has examined whether two different types of crime (burglary and theft from motor vehicles) were spatio-temporally connected (Johnson, Summers, & Pease, 2009). The aforementioned study focused, as have most other studies in the near-repeat framework, exclusively on acquisitive crime and the general clustering of crime in space and time.

The present work goes beyond the earlier work by testing whether *different* phenomena, in this case shootings and police arrests for illegally carried firearms, are linked spatio-temporally, using a modified version of the Knox (1964) close pair method to describe the patterning. The Knox close pair method was originally developed to uncover clustering in space and time of cases of childhood leukemia but has since been used to analyze the patterning of other diseases and more recently acquisitive crime (briefly described above) and shootings.

Implications of focus

In sum, the current study should improve upon prior research in several ways. Finer, point-based data sources permit detailed disaggregate examinations of spatio-temporal shootings-arrest links. Looking at those links in a more disaggregated form may align the examination more closely with the corresponding police and offender dynamics. By describing the spatio-temporal associations between police arrests for illegally carried firearms and shootings this work should advance our understandings of police responsiveness to crime and ecological deterrence. The spatio-temporal patterns observed potentially highlight or eliminate some of the proposed theoretical processes from different theoretical models that have been used in the past to account for arrest/shootings relationships. For example, an excess of arrests across a broad geographic area following a shooting may suggest a concerted district-wide police effort to address illegal firearm carrying rather than police responding locally based on highly localized knowledge. Additionally, a pattern of fewer shootings observed than expected in a large sized spatial area following a firearm arrest might suggest that the transmission of the threat estimate may not be a local process working through limited social networks. Practically speaking, results may provide potentially useful strategic information to law enforcement agencies, perhaps assisting in problem-oriented deployments or interventions that are more attuned to the spatial and temporal dynamics (or nuances) of violent criminal behavior.

CHAPTER 2:

CONCEPTUAL AND EMPIRICAL BACKGROUND

The broad goal of the current work is to understand more fully the relationship between one type of violent crime, shootings, and one class of policing activity, arrests for illegally carrying firearms. Because of the non-recursive, “snake-biting-its-tail” nature of these dynamics, the present investigation will examine these links at smaller temporal and spatial scales than previous work has done. Doing so allows some degree of separation of links between shootings to later police firearm arrests, from those links between police firearm arrests and later shootings.

Moving down to a finer-grained perspective so these two links can be separated means, in essence, that the current work explores new patterns. This is because the scholarship on spatial and temporal aggregation, the ecological fallacy, macro-micro links, and the modifiable areal unit problem all warn us that different dynamics and different patterns may emerge when spatial or temporal scales, or both, are shifted (Hannan, 1971; Liska, 1990; Openshaw, 1979; Robinson, 1950). Therefore, the relevance of earlier conceptual frameworks and empirical results based on more macro-level dynamics is not known. These earlier works nevertheless provide a broader context for the current work, underscore the need for the current work, and provide conceptual starting points for developing the theoretical framework appropriate to the current micro-level investigation. So they will be reviewed to provide a broader backdrop.

The section is organized as follows. Ecological work on police responsiveness to crime is reviewed. Empirical patterns observed and suggested explanatory mechanisms are noted. Key findings and conceptual and empirical limitations are described. Given suggestions made in this area, a conceptual frame for the current study's examination of this link is outlined. Then ecological work on impacts of police actions generally on later crime, including geographically targeted enforcement around firearms and later shootings, is reviewed. Key findings are highlighted, and again, conceptual and empirical limitations noted. Conceptual development for the current consideration of this link is done, again starting with existing theoretical orientations. The next section summarizes the limitations to date for work on both these links. A more complete conceptual framework follows for considering the micro-level spatio-temporal links examined here. The section closes with a statement of the two questions investigated, and closing thoughts on the patterns that might emerge and what they might mean.

Later police responses to earlier crime

Several researchers have explicitly focused on documenting how changes in police outputs like arrests represent responses to earlier crime changes (Decker & Kohfeld, 1985; Jacob & Rich, 1980; Kohfeld, 1983; Kohfeld & Sprague, 1990). Some examples follow.

The work

There is a logical reason to believe that a positive association exists between level of crime and number of arrests. Jacob and Rich (1980) posited that as police respond to increasing crime conditions they may make more arrests, recording more crime, thereby generating a positive correlation between crime rates and arrest rates. Jacob and Rich (1980) noted that they have "no direct evidence," but the direction of the relationship between arrests and crime suggests that citizens recognize changes in offending and may be more likely to call the police, therefore increasing recorded crime rates (Jacob & Rich, 1980: 121).

Kohfeld (1983) drew a similar conclusion. Focusing on annual robbery and robbery arrests rates in St. Louis during the years 1948 to 1978, Kohfeld (1983) found a positive correlation between earlier robbery rates and later robbery arrest rates. She justified the focus on robbery by arguing that robbery and other violent crimes, the crime categories with the largest correlation, were the types that got the most publicity, and therefore placed additional pressure on the police to make arrests. Regarding the underlying dynamics, Kohfeld (1983) proposed that robbers were neither sensitive to nor aware of information concerning police clearance rates from the prior year, but that police did have information about the location and trends of robberies. Law enforcement personnel, therefore, were likely to respond to shifting robbery patterns by allocating additional resources to areas where they observed robberies going up.

Decker and Kohfeld (1985: 439) also anticipated that if "police are moderately good at their job," then as crime increases so should the number of arrests. Using St. Louis data from 1948 to 1978, a generalized least-squares procedure, and lagged raw numbers of arrests – i.e., placing arrests after crime – they found significant positive relationships for most crimes: the effect of crime on later arrests was significant and positive. The authors noted extremely high positive first-order correlations for raw numbers of crimes and number of arrests for each offense type. When they reversed the temporal ordering – earlier arrests and later crimes – they found negative but non-significant relationships. In interpreting their results, these authors concluded the results suggested that "arrests are a response to criminal behavior" (Decker & Kohfeld, 1985:

448). The findings were in-line with their original premise that a police department "undoubtedly responds to criminal behavior, and one therefore ought to expect that when the number of crimes increases, so do the number of arrests" (439).

In another St. Louis study focusing on census-tract level, weekly changes in burglary and all arrests over a ten-week period, Kohfeld and Sprague (1990) found that arrests follow crime. The authors posited that police would respond almost instantaneously -- in less than a week -- to changes in criminal activity. If crimes are reported and their patterns regularly assessed, police could know in very short order about these shifts. Such updated knowledge, of course, may or may not be transmitted as directives to patrol officers (Famega, Frank, & Mazerolle, 2005). Kohfeld and Sprague (1990) also posited that this link and the other one of interest – effects of police action on criminal behavior – could *both* be moderated by characteristics of the locale. This point aligns with other empirical and theoretical works on police responsiveness (Klinger, 1997; Smith 1986).

Conclusions and limitations

In general then, these works support the idea that there are associations between later arrests and earlier crime levels, and that these may result from informed and responsive police administrators and patrol (Decker & Kohfeld, 1985; Jacob & Rich, 1980; Kohfeld, 1983; Kohfeld & Sprague, 1990). Assuming police are aware of changes in criminal activity and police administrators react to more crime by allocating more resources (more officers) and/or emphasizing intensive patrolling in these areas, there may be a greater number of arrests. The relationship appears when the temporal lag ranges from a week to a year and the spatial unit ranges from census tracts to a city.

Work on this link is limited, however, in at least two ways. (1) Most studies that have hypothesized police personnel respond to changing crime patterns and that have resulted in a positive correlation between crime and arrests have examined changes across entire cities (e.g. Decker & Kohfeld, 1985; Jacob & Rich, 1980; Kohfeld, 1983). These cities and cities in general may be so large they mask or swamp dynamics which may be ecologically linked to more delimited spatial arenas. The emphasis on hot spots and hot spots policing that has emerged in the last twenty years directs attention further down the cone of resolution (Sherman, Gartin, & Buerger, 1989; Taylor, 1998). (2) Not only do the majority of studies determining if police personnel respond to changes in crime by making more arrests use large spatial units, the majority of studies used large time aggregations, examining changes over one year (e.g. Decker & Kohfeld, 1985; Jacob & Rich, 1980; Kohfeld, 1983). Kohfeld and Sprague (1990), who have posited that police respond immediately to criminal behavior whereas criminals' response to police behavior is delayed, have argued that data analyzed yearly, quarterly, or monthly may insufficiently identify the differential patterns of police responsiveness to crime events.

An extended conceptual framework for the link

The extended conceptual framework for positing more fine-grained connections between earlier shootings and later police firearm arrests builds on some of the above points.

The first extension is to focus on firearm violations rather than shootings arrests. Instead of supposing that police respond to shootings by increasing the number of shootings arrests, a plausible but untested assumption is that police shift attention towards detecting and confiscating illegally carried firearms as a means to reduce shootings.

A greater number of firearm arrests may occur after a shooting for three reasons. First, a considerable amount of policing is incident-driven (Parks, Mastrofski, Delong, & Gray, 1999). When citizens call for service, police are expected to respond rapidly and attend to the request; this is especially true when a serious incident such as a shooting occurs. Second, research has suggested that, except in the case of extended domestic disputes and a few other crimes, even with a rapid response police rarely arrive to the scene of a crime in progress. Calls for police services are generally in response to a crime and, although there are exceptions, by the time police arrive the perpetrator has left the scene (Altbeker, 2005). Third, in addition to responding to a specific scene of a problem that they were dispatched to, police may patrol (in a vehicle or on foot) in or near the problem areas (Herbert, 1997). Whether responding to the scene of a shooting or patrolling in or near an area that has experienced a shooting, police may seek to increase the number of contacts with citizens via car and pedestrian stops, hoping to detect more illegal firearm carrying, resulting in more arrests. In sum, a likely scenario entails police receiving a call about a shooting, arriving quickly to the location of the incident, but not fast enough to witness the shooting and then engaging in a number of police-initiated contacts that may result in the discovery of firearms. Therefore, changes in the number of arrests that involve the illegal carrying of a firearm might be a more realistic and appropriate measure of informed and responsive police administrators and patrol than arrests for shootings would be.

The second extension is to emphasize how localized police responses may be, because the events to which they are responding may be highly localized. Crime may be concentrated within very small spatial units, even smaller than census blocks, which are subdivisions of census tracts (Weisburd, Morris, & Ready, 2008). Crime is concentrated at places (Weisburd, Bruinsma, & Bernasco, 2009). Recognition of hot spots (Sherman, Gartin, & Buerger, 1989) has led naturally to proposals for hot spots policing (Mastrofski, Weisburd, & Braga, 2010).

Policing is similarly spatially concentrated. In a qualitative study of police officers in Los Angeles, California, Herbert (1997) observed that police respond to a shooting by forming a perimeter on each of the four streets forming the block surrounding the scene to apprehend a fleeing suspect. In addition to erecting a perimeter to seal a square block, officers will circle "at a distance of two or three blocks" to the last reported location of the incident (1997: 105). Further, a more delayed response may occur as police accumulate information about the location and trends of crime and shift additional resources to these areas causing an increase in the number of arrests.

So it seems likely the police response to shootings will be fast and localized, and Herbert (1997) has provided some evidence of how localized.

In terms of how quickly police respond to criminal activity, Kohfeld and Sprague (1990) found responsiveness with a lag of a week. It seems plausible it could be even faster. Although the exact amount of time is not specified, research suggests that police respond to changes in criminal activity with "immediacy" (Kohfeld & Sprague, 1990: 112). Others (see, D'Alessio & Stolzenberg, 1998) have drawn similar conclusions that "criminal activity has a relatively immediate impact on arrest levels" (753).

In the sped up 24/7 news cycle of the last decade, such a response might be very fast. John F. Timoney (2001), former police commissioner of both the Philadelphia Police Department and Miami Police Department, remarked that local news coverage starting at 5 a.m., again at noon, and again in the early and late evening, brought considerable attention to and pressure on what police were or were not doing in response to serious local incidents. Given these pressures, it seems plausible to expect to observe police being responsive to shootings inside of a week's time frame, perhaps within a day or two.

Earlier police actions and later crimes

The empirical work linking earlier police actions and later crimes is quite diverse. It focuses on a broad range of police actions, including firearm carrying itself, and often relies on some type of ecological deterrence model.

The work

This section starts with the work at higher levels of aggregation and broader outcomes, then moves on to consider the more geographically targeted work, then takes up the rationales for firearm arrests and how they might create deterrence.

Starting with the city-level work, studies present confusing patterns of results, some of which may be due to problems with ratio variables.

In a seminal cross-sectional study of 35 large cities in the United States, Wilson and Boland (1978) used 1975 data and found that as the percentage of robberies leading to arrests increased, the rate of robberies committed decreased. Their finding seemed to support a deterrence doctrine since, as legal punishments in the form of arrests per crime increased, crime decreased.

Jacob and Rich (1980) looking at some of the same data, however, found a positive relationship between arrest rates and crime rates. Using time-series data between 1948 and 1978 and one and two-year lags, in six of nine cities originally considered by

Wilson and Boland (1978), as the number of arrests increased, so too did later robbery rates.

Jacob and Rich (1980) argued that the divergent findings were in part due to the inappropriate inclusion of common terms in the ratio variables (robberies/population and arrests/robberies) employed by Wilson and Boland (see Wilson & Boland, 1981 for a rejoinder). When a common component such as number of robberies is used in the numerator of one variable and the denominator of another, the results have a built-in tendency towards negative association (Long, 1979). Kohfeld (1983) described the same phenomenon to explain the results of her 1983 analysis of robbery rates and time-lagged robbery arrests in St. Louis between 1948 to 1978.

Decker and Kohfeld (1985) drew a similar conclusion after comparing annual reports of regression results of homicide, robbery, and burglary arrest rates across St. Louis from 1948 through 1978. They contended that arrest ratios, i.e., clearance rates, were inappropriate deterrence measures since criminals were unaware of subtle changes in the proportions of crime cleared by arrests but might be cognizant of an increase in the sheer number of arrests.

The ecological deterrence literature is far more extensive than is presented here, and includes studies examining deterrence at the city level with a year lag (Greenberg & Kessler, 1982; Greenberg, Kessler, & Logan, 1979; Greenberg, Kessler, & Logan, 1981) or a day lag (D’Alessio & Stolzenberg, 1988), as well as some work at the police district level (Taylor et al., 2009). That work is not reviewed in detail here given its scope and perhaps limited relevance, and in light of the size of the spatial and temporal units used in the current work. The broader theoretical frame within which that work is conducted is nonetheless examined and extended later in the section.

Turning to more localized patterns of police impacts on later crime, the general results are somewhat less confusing. Geographically targeted policing does appear to be associated with reduced crime across a wide range of crimes, even though the impacts may be short-lived (Skogan & Frydl, 2004). This general pattern aligns with work on crackdowns in areas such as speeding and drinking and driving. For example, in his review of the deterrence approach to controlling drinking and driving, Ross (1982) concluded that short-term deterrence was often attained but reductions, and by inference deterrence, were not enduring. He suggested that people might be initially deterred due to an overestimation of the likelihood of apprehension and punishment. Later experiences, however, may convince them that the risk of apprehension and punishment is negligible, and so they are not deterred.

Turning to illegal firearm carrying next, attention is focused on the rationale in favor of police efforts directed to this behavior, counter-arguments, then the results, and finally the broader conceptual framework underlying these models.

Focus on illegal firearm carrying: Rationale, procedures, and counter-arguments

Many homicides and other predatory crimes are unplanned, carried out by armed people acting impulsively in public places. Moore (1980) was one of the first to argue that illegal firearm carrying bred violence and it was reasonable to expect that carrying a firearm into public places increased the likelihood of lethal violence.

There are numerous reasons for people to carry firearms illegally (e.g., to create or maintain a positive social identity in certain neighborhoods, for self-defense, or to commit a crime). The mere presence of a firearm, however, may turn a conflict lethal as people think firearms can help handle disagreements (Moore, 1980). Ethnographic work by Wilkinson and Fagan (1996) with serious violent young offenders has supported Moore's assertion that firearms are seen as legitimate tools for resolving disputes. Further, people who casually carry a firearm during their daily activities may take advantage of those perceived to be vulnerable. A large part of firearm violence in the United States is a result of "young guys walking or driving around with guns and then doing stupid things with them" (Ludwig as quoted in Dubner, 2008: para. 4). Therefore, reducing the illegal carrying of firearms seems like a reasonable and effective police aim for preventing firearm violence (Kleck, 1991; Moore, 1980).

What are the ways police might achieve that aim? Moore (1980) summarized some mechanisms that may lead police to make arrests for the illegal possession or carrying of a firearm. First, the discovery of a firearm may be a by-product of enforcement activities geared toward other offenses. Reactive investigations into serious crimes such as rape or murder might result in a weapon arrest once suspects or people of interest are questioned and searched. Additionally, proactive investigations of illegal narcotics or extortion rackets may lead to weapons arrests for similar reasons. Random patrol operations primarily designed to respond to calls for service and enforcement of traffic violations may lead to firearm arrests. Police responding to a call of a discharged firearm may arrive quickly at a scene and make an arrest, or when a police officer stops a person suspected of driving under the influence, a subsequent frisk of the driver may reveal a firearm (Moore, 1980). In addition to weapons arrests as by-products of other activities, these arrests might result from special organizational initiatives. In a study in five large cities, Moore (1980) discovered that cities with more aggressive police forces (measured by total arrest rates for drunkenness and various part II offenses reported in the Uniform Crime Reports) generated higher numbers of weapons arrests.

What Moore (1980) termed aggressive policing therefore calls for proactive strategies to confiscate illegally carried firearms by maximizing the number of police-citizen contacts, ensuing frisks, and/or ensuing searches of pedestrians or automobiles to increase probabilities of detecting illegally carried firearms. Pedestrian stops are an important tool for police: among other things, they generate information about criminal activity or identify those who have outstanding warrants (Rudovsky, 2001). The Supreme Court has ruled that in order for police to forcibly stop or detain a person, a police officer must have a reasonable suspicion that the person is involved in criminal behavior. Further, when a police officer fears for his or her safety, the police officer may frisk the subject's outer layer of clothing to detect weapons (Fyfe, 2004).

In addition to pedestrian stops, police rely on automobile stops and searches to detect and confiscate firearms. When police witness a traffic violation they may stop the vehicle; firearms in plain view may be seized and constitute probable cause for arrest. Furthermore, during the stop an officer might secure consent to search the person or the vehicle, potentially leading to the discovery of firearms. Lastly, during a stop if the officer feels a person in the vehicle presents a danger to the officer, the officer may frisk the subject. Again, a firearm might be detected (Rudovsky, 2001). Efforts to increase pedestrian and automobile stops that may result in the detection and confiscation of illegal firearms have included increasing the number of police officers, encouraging more police-citizen contacts, and freeing police from calls for service.

There are, of course, serious counter-arguments to such policing procedures. For example, scholars question whether the police tactics will be racially neutral (Fagan & Davies, 2000) and whether, even with training, police are capable of carrying out searches where a high proportion of their stops, even at high gun crime times and high gun crime places, will result in a confiscated weapon (Moss-Coane, 2006; 2008). Intrusive policing can be very tough on innocent citizens (McArdle & Erzin, 2001). But proactive policing which results in the detection of illegal firearms also, at least from the literature below, can get firearms off the street and increase safety.

Focus on illegal firearm carrying: Results and limitations of the work

At least eight published studies have suggested that concentrated police efforts may deter illegal firearm carrying and subsequent shootings (Sherman, 2003).[1] Arguably the most widely known study regarding the effectiveness of directed police patrol and firearm seizures to reduce shootings was conducted by Sherman and Rogan (1995) in Kansas City, Missouri. It is presented in detail, as are two others which sought to replicate it. Of course, questions remain about how effective these efforts are, and these concerns and limitations are then noted.

Using a quasi-experimental design Sherman and Rogan (1995) tested whether greater enforcement of laws prohibiting the carrying of concealed weapons would reduce shootings. Beginning July 7, 1992, and ending January 27, 1993, the Kansas City Police department deployed extra patrol officers in a target beat (.64 square miles) with an extremely high homicide rate that was several times the national average. Officers working overtime were not required to answer calls for service but instead concentrated

[1] For a systematic review on the impact of police crackdowns on firearm crime see Koper & Mayo-Wilson, 2006.

on firearm detection via safety frisks, those seen in plain view during traffic stops, and searches incident to arrest on other charges (Sherman & Rogan, 1995).

Before the intervention, during the first six months of 1992 there were 46 firearms seized in the target beat. By contrast, in the last six months of 1992 with directed patrol of firearm hotspots, there were 76 firearm seizures (Sherman & Rogan, 1995). Additionally, firearm crime went down in the target beat. Eighty-six firearm crimes were reported during the six months of intervention compared to the preceding six months (169), nearly a 50% decline. Importantly, a comparison beat not receiving increased patrol showed no significant changes in the numbers of firearms seized or firearm crimes. Firearm crimes did not increase significantly in any of the seven beats adjacent to the target areas, suggesting no spatial displacement of firearm crimes. Others have attempted to replicate the finding from this seminal study to better understand reducing firearm violence.

An attempted replication in Indianapolis in 1996 used a pre-posttest quasi-experimental design with a non-equivalent control group (McGarrell et al., 2001). The treatment areas were two police beats that received directed patrol and additional officers. The two treatment beats had some of the highest rates of drug distribution, violent, and property crimes. Researchers compared changes in the number of firearm seizures and firearms-related violent crime for the 90-day period during directed patrol with the same 90-day period in the prior year. Additionally, changes in two treatment areas were compared with changes in citywide crime (McGarrell et al., 2001).

Important design differences between the Kansas City and Indianapolis study include using two target beats rather than one, and a much larger treatment area, approximately four times larger than the target beat in the Kansas City study.

Illegal firearm seizures were higher in the Indianapolis target beats (north and east) receiving directed patrol compared to the same period a year earlier. A total of 42 firearms were seized in one target area and 45 firearms were seized in the other target area, representing, respectively, 8% and 50% increases compared to the same period a year previous (McGarrell et al., 2001).

The strength and success of the treatment, and how it was implemented varied, however, across the two Indianapolis police beats. Although the number of officers assigned to each target area was not specified, McGarrell et al. (2001) noted the north target area received considerably fewer officer hours than the east target area. In the north beat, officers were instructed to be more selective in whom they stopped, focusing specifically on those “suspected to be involved in illegal behavior” (130). Here, firearm crimes decreased by 29%, other firearm assaults and armed robberies dropped 40%, and homicides decreased from seven to one compared to the same 90-day period the year previous. In the other target area, the east beat, with more officers, there was a decrease in homicide compared to the same period a year previous, from four to zero, but total firearm crimes increased (McGarrell et al., 2001).

McGarrell et al. (2001) conducted a more global series of analyses using interrupted time-series. Changes in firearm crimes in the target areas were compared to changes in the city as a whole (target beat totals were excluded from the city totals). Data spanned 158 weeks prior to the intervention, 13 weeks during the intervention, and 13 weeks post-intervention. An increase of about 1.5 firearm crimes per week appeared in the rest-of-the-city comparison area, whereas there was a decrease of about two firearm crimes per week in the north beat treatment area, and no change in the east beat treatment area (McGarrell et al., 2001). A slight but non-significant increase in firearm crimes in the five beats surrounding the two treatment beats appeared.

Regarding citizens' reactions, McGarrell et al. (2001) noted strong public support for the police and for the directed patrol strategy, and zero complaints filed with the department about the directed patrol project. This was despite a total of over 5,000 vehicle stops and 992 arrests (84 felony, 654 misdemeanor, and 254 warrant) and treatment areas in predominantly African-American and low-income communities. The authors' comments notwithstanding, there was no systematic surveying of residents in treatment and comparison areas to learn how their views of the department and local police might have shifted during the program. Views about local police departments can shift in short time frames (Tuch & Weitzer, 1997).

The second attempted replication took place in Pittsburgh. After identifying perceived limitations of both the Kansas City and Indianapolis studies, Cohen and Ludwig (2003) presented results of a police program targeting illegal firearm carrying that sought to "isolate the impact of the police patrols from the effects of other confounding factors that cause crime rates to vary across areas and over time" (219). Two of the city's six patrol zones received extra evening patrols for a 14-week span (7/1998-10/1998). Police in the intervention areas were to work proactively, focusing on the detection of illegally carried firearms and not responding to citizen calls for service. The two intervention patrol zones were about nine square miles each with approximately 55,000 and 80,000 residents, and had the highest crime rates in Pittsburgh.

Seeking to avoid using control areas located elsewhere, directed police patrols only occurred Wednesday through Saturday within the target areas permitting the comparison of treatment and control days within the same locations (Cohen & Ludwig, 2003). Daily time-series analysis showed treatment days associated with reductions in both shots fired (34%) as reported to police and hospital-treated assault gunshot injuries (71%). During the treatment days (14 x 4 = 56) two firearms were confiscated in one patrol zone, 12 in the other (Cohen & Ludwig, 2003).

Conclusions and limitations

What conclusions are suggested by these works on police patrol-based firearm interdiction? Studies of intensive police patrol in areas with high levels of shootings have produced results suggesting intensive patrol in places with high violent crime rates may reduce shootings. Overall, Koper and Mayo-Wilson in their 2006 systematic review on the impact of police crackdowns on illegal firearm carrying and firearm crime concluded that "directed patrols focused on illegal gun carrying reduce gun violence at high-risk places and times" (248). Furthermore, Sherman (2001) has argued that uniformed patrol of firearm hot spots is one of only a few strategies aimed at reducing firearm violence that is known to "work" (17).

How solid is this conclusion? This group of studies has weaknesses. Koper and Mayo-Wilson (2006: 248) in their systematic review noted that the "inferences are limited" due to a "small number of available trials (which were not all independent), variability in study design and analytical strategies, and the absence of randomized trials." Of course study proponents such as Sherman (2003) have argued that great care was taken to make comparison areas comparable to control areas to better "draw substantial inferences even without random assignment" (243). But, Koper and Mayo-Wilson (2006) have cautioned that the target areas and comparison areas may differ in significant ways, and firearm reductions may have resulted from regression to the mean.

Perhaps even more importantly, as McGarrell et al. (2001) warned, the causal mechanisms producing the reduction in firearm crime as a result of directed patrol remains unclear. They hoped future studies would "isolate the causal mechanisms of directed patrol initiatives" (145). If the studies had found roughly spatially or temporally corresponding increases in firearms confiscated and decreases in shootings or injuries reported, it would be clear that firearms were being removed and shootings were decreasing correspondingly. But since firearms removed seem so low in many of these studies, the process may not involve firearm removal. Sherman has suggested either that those who usually carry firearms will leave them home if going into a directed patrol area, or will avoid the area altogether (Moss-Coane, 2006; 2008). The bottom line is if this strategy is working, the relevant dynamics are not clear.

An extended conceptual framework for the link

If this strategy is causing real reductions in shootings and related injuries without corresponding increases in firearm confiscations, some type of deterrence process might be involved. The key to controlling firearm violence, according to Moore (1980), is through arrests and successful prosecutions of people who illegally carry firearms. These actions will incapacitate some potentially dangerous individuals and deter less dangerous others from casually carrying firearms. If people knew police were likely to seize firearms in certain places they should be less likely to carry firearms illegally in those areas. Potential offenders would avoid illegally carrying a firearm because others have been apprehended and punished (general deterrence). Also, individuals who were found illegally carrying a firearm may be less willing to do so again due to fear of additional punishment (specific deterrence) (Nagin, 1978) as well the hassle and expense of replacing a firearm (Sherman & Rogan, 1995).

Deterrence is one of the most complex and challenging areas in criminological theorizing (Greenberg, Kessler, & Logan, 1981; Nagin, 1998; Nagin & Paternoster, 1991; Paternoster & Piquero, 1995). A systematic review of the theory is beyond the scope of current work. It also is not appropriate because the current work is an exploration of micro-level spatio-temporal patterning, not a test of deterrence theory. But it is appropriate to consider previously cited limitations in ecological deterrence work, and how deterrence issues intersect with questions about spatial and temporal aggregation and disaggregation, and how deterrence theorizing suggests what localized social processes may underlie the effectiveness of directed patrolling.

Research has recognized that the findings of deterrence studies are "sensitive to the levels of spatial aggregation" (Chamlin et al., 1992: 379). Since at least 1973, Cousineau has warned that areal units used in ecological deterrence research are often too large to be homogenous social units and even smaller units of analysis are sometimes heterogeneous. Furthermore, these fixed boundaries may conflate or not capture the ecological distribution of homogenous social units, which he argued is desirable for ecological deterrence research (Cousineau, 1973). Kane (2006) adds "the identification of the spatial unit of aggregation that best estimates the potential for the transmission of sanction-related information via social networking across territorial areas" (190) is paramount to ecological deterrence research.

Chamlin et al. (1992) also argued that large, often heterogeneous units are inappropriate for testing the efficiency of police to deter crime. The transmission of information concerning police activity to potential offenders is most likely to be conveyed within neighborhoods rather than within larger areal aggregations (Bursik, Grasmick, & Chamlin, 1990). For example, localized processes in different neighborhoods may significantly influence the ability of law enforcement to detect illegally carried firearms and the effectiveness of seizures on reducing shootings. A neighborhood resident's willingness to notify law enforcement about suspicious people might lead to a greater number of confiscated firearms. Additionally, certain neighborhood dynamics may encourage the sharing of information via secondary informal social networks; residents in these neighborhoods may be more likely to become aware of the police presence (and the potential/likely punishment associated with arrests and convictions) than residents in neighborhoods characterized by less interaction among neighbors.

It is incorrect to assume the risks of punishment to be invariable within urban areas (Bursik, Grasmick, & Chamlin, 1990). Mastrofski, Weisburd, and Braga (2010) noted there is "considerable variation *within* the larger geographic spaces police" organize their activities (251). They go on to argue that being sensitive to these micro-variations "will yield substantial gains" in determining the effectiveness of police action on crime (Mastrofski, Weisburd, & Braga, 2010: 251). Even with the knowledge that risks of punishment vary across spatial units the degree of variation within these spatial units “is an empirical question” (Bursik, Grasmick, & Chamlin, 1990: 434).

Temporal variation is relevant as well. The appropriate temporal level of aggregation should match the dynamics implicit in triggering processes of deterrence; unfortunately, deterrence theory provides very “little guidance” in the selection of the lag (Bursik, Grasmick, & Chamlin, 1990: 436). Thus far ecological deterrence impacts have been found to appear in very short order, for example within a day (D’Alessio & Stolzenberg, 1998) or three months (Taylor et al., 2009), but not when a lag of a year is used (Greenberg, Kessler, & Logan, 1979).

In short, theoretical consideration about the spatial heterogeneity of policing activities in a location, and the work in ecological deterrence suggesting such processes can happen on short time or spatial scales, drives attention to more micro-level dynamics. There are additional theoretical considerations also directing attention to the micro-level. These concern the role of indirect experience learned from others in one’s social network.

Risk perceptions will be based not only on one’s own experiences, but also those in one’s social networks (Cook, 1979). Others have drawn similar conclusions; Tyler (1984) noted that people rely in part on others’ experiences to develop perceptions of risk. Furthermore, a study of burglary offenders revealed they in part calculated their risk of apprehension through not only their own experiences but also via social networks (Parker & Grasmick, 1979).

More recently, Stafford and Warr’s (1993) reconceptualization of deterrence theory made similar points. Deterrence may operate not only as a result of punishment in the traditional sense, but when people avoid punishment they may be less likely to view law enforcement as competent and therefore feel safe committing more crimes. Specifically for illegal firearm carrying, Stafford and Warr (1993) argued that direct experience with apprehension and punishment for various crimes might diminish future illegal firearm carrying. If one consistently commits crimes without being detected, however, and/or hears about others who have done so, he or she may feel more confident in illegally carrying a firearm. The same holds true with indirect experiences with punishment and punishment avoidance. Offenders might know others who have been arrested or people who have committed crimes and were not detected, thereby influencing the offender's perceptions of apprehension and thus their own behaviors.

In the case of illegal firearm carrying, perceptions of apprehension risk may be produced primarily by impressions shaped by the police being proactive in enforcement activities (Sherman & Rogan, 1995). Potential offenders may be less likely to offend initially as they fear detection by authorities, but the uncertainty of further police presence also may escalate fears of apprehension and longer-term or residual deterrence (Sherman, 1990).

The conceptual implications, then, of the above suggested dynamics, are the following. First, when considering the impacts of police firearm arrests on later shootings it makes sense to focus on the most immediate social surrounds, because it is through these localized networks that others will learn about the firearm arrests. Urban residential street life is organized on the streetblock basis in the core neighborhoods of older eastern industrial cities (Taylor, 1997). This suggests an arena around a shooting with about a 400 foot radius, comparable to a streetblock's length. Of course, residents have social ties off the block and nearby, so impacts spreading to nearby blocks also may show patterns of decreased shootings following firearm arrests.

Second, research has observed deterrence effects taking place within a day (D'Alessio & Stolzenberg, 1998). Further, as described in the above dynamics, and as noted earlier in the work on crackdowns, impacts of more intensive policing action can fade quickly (Ross, 1982). Therefore it makes sense to concentrate at the scale of days rather than weeks.

Two additional dynamics previously identified in work on geography and crime prevention deserve consideration in the proposed theoretical model: possible crime displacement or diffusion of benefits.

Theoretically, enforcing laws forbidding the unlawful carrying of firearms in certain areas could result in some degree of spatial displacement of both firearm carrying and firearm crimes. Diffusion of benefit, of course, is also possible and has been observed more often than displacement (Clarke & Weisburd, 1994). Crime does not necessarily spill over into close areas, but instead crime might be reduced in areas surrounding the intervention areas (Clarke & Weisburd, 1994; Eck, 1993). Potential offenders may believe that intervention strategies such as increased police enforcement activities have been implemented more widely than the actual target areas and/or for a greater time period (Clarke & Weisburd, 1994; Eck, 1993). These potential offenders may also believe that they are at an increased risk that they will be detected and apprehended for illegally carrying a firearm.

Evidence for a diffusion of benefit to surrounding areas has been found in various crime control efforts. For example, research examining increased street lighting (Painter

& Farrington, 1999) and directed police patrol in drug hotspots (Weisburd & Green, 1995) both discovered a diffusion of benefit. Overall, however, measurement of displacement and diffusion of benefits is extremely difficult, and in general there has not been extensive empirical research in this area (Ratcliffe & Makkai, 2004). Koper and Mayo-Wilson (2006) noted in their systematic review of police crackdowns on illegal firearm carrying that research in this area "did not consistently address crime displacement in its various manifestations" (250).

Furthermore, arguing against displacement, Sherman and Rogan (1995) speculated based on the tenets of routine activities theory that displaced firearm crimes occurring outside target areas will be substantially lower than those in the high risk target areas. In lower risk, non-targeted areas there should be fewer interactions between likely victims and armed predators carrying firearms; therefore, increased enforcement of laws against people illegally carrying a firearm may still reduce firearm crime. Data relevant to this argument, however, are lacking.

The implication for the current project is that although impacts of police firearm arrests on later shootings are expected to be highly localized, given the information-based and social dynamics discussed earlier, it may be important to consider spatial and temporal frames that go beyond a few days or a few blocks. Therefore, the current work will consider links between firearm arrests and later shootings for up to a half mile away, and up to 14 days later. It is expected, however, that the clearest patterns will be seen in the areas closest to the initial arrest, and very soon after.

A final consideration is the relevance of local community context. The earlier work has pointed out that impacts of police actions may be moderated by community fabric (Kohfeld & Sprague, 1990). Therefore it may be important to consider the way this link works in different parts of the city, with different community composition and violence levels.

An alternative view of the link

Theories about police responsiveness have dominated the discussion about the impacts of crime on later police activity. Theories related to incapacitation and, more prominently, to deterrence have dominated the discussion about the impacts of police firearm arrests on later shootings.

Alternative perspectives on firearm arrest impacts deserve mention, perspectives where shootings might increase after a firearm arrest. First, police arrests following a shooting are just one event in what may be an ongoing string of violent events. It is certainly possible that firearm arrests also might represent the police disrupting criminal networks. This could lead to an increase in conflicts and shootings.

Second, it is possible to conceptualize the second link in ways that align with the first question looking at how police respond to shootings. Police officers might be drawn, through information received and experiences witnessed, to exceptionally violent areas where they proceed to make firearm arrests. The firearm arrest can be conceptualized as an indicator of police responsiveness, pointing to a time and place where previous shootings, or the associated dynamics (Timoney, 2001) escalated to the point that police made a firearm arrest.

This is saying more than that the arrest pinpoints a hot spot. Hot spots are defined as being high crime places over a year or two (Sherman, 1995). But within a hot spot, or outside a hot spot, there may be places where violence in the form of shootings flares up for a time. Indeed that is the message of the work on near-repeat shootings in Philadelphia (Ratcliffe & Rengert, 2008). Police firearm arrests might best be interpreted as “tells,” pointing to a time and location where a violence flare-up was in progress, and police intervened to try and reduce the violence. If this perspective is appropriate, it would suggest that areas near a firearm arrest might experience high counts of shootings soon after because the violence flare-up was continuing despite the police intervention, or was continuing but at a lower level than it would have had the arrest not occurred, or perhaps was heightened because of the police intervention.

Exploration framework, rationale, and constraints

The current work considers two questions:

1) Do locations near a shooting experience more arrests for illegal firearms soon after the shooting compared to what would be expected based on chance?
2) Do locations near a firearm arrest experience fewer (or perhaps more) shootings soon after the firearm arrest compared to what would be expected based on chance?

For both of these questions, albeit for different reasons and with reference to different dynamics, the case has been made that spatio-temporal patterning of the links needs to be explored at a more micro-level than has previously been researched.

This investigation is needed because earlier work on both these questions a) has found variability in results depending on how the data are organized, b) has been unable to provide conceptual clarity on the relevant processes which drive these connections, and c) has pointed out the need to investigate more micro-scaled dynamics. In addition, there could be multiple, overlapping, related processes working at different levels, which have not been discovered in previous studies and has not used the currently available methods and frameworks.

The patterns that could appear at the micro-level when considering shootings following firearm arrests could present more diversity in results than has been seen in the more macro-level work, and for sound theoretical reasons. A rough extension of Stafford and Warr's (1993) indirect experience deterrence idea, relying on very localized networks of information, would suggest fewer shootings nearby and soon after a firearm arrest. But if perceptions are skewed, the fewer shootings might be temporally but not spatially patterned. Further, the quick evaporation of impacts suggested by some of the crackdown literature (Ross, 1982) might mean that the shootings reductions are very short lived, perhaps too short lived to detect, depending on the background shootings rate. Finally, a police responsiveness take on firearm arrests views these arrests as police activity-based pointers to times and places when violence is flaring up. In this instance, the firearm arrest is construed not as having an impact, but rather as an organizational response centered spatially and temporally on a violent flare-up involving firearms. The violence flare-up may be exacerbated by the police arrest, may be dampened by the police arrest, or may only be affected if there are numerous arrests. Of course, given the endogeneity problems here, going from links to impacts is difficult.

The challenge now is to locate a technique that permits the proposed micro-level explorations. The Knox close pair method (introduced in the previous chapter and elaborated on in the next chapter) can be appropriately adapted for current purposes.

CHAPTER 3:

DATA AND METHODOLOGY

Police data

The data used in this study are comprised of shootings, including criminal homicides, robberies, and aggravated assaults by firearm, as well as Violations of the Uniform Firearms Act (VUFAs) occurring within the City of Philadelphia from January 1, 2004 to December 31, 2007. These data were obtained from the Philadelphia Police Department's Incident Transmittal System (INCT).

The INCT data are primarily the result of two sources, citizen-prompted police response and police initiated responses. Citizen calls placed to 911 are transmitted to the Philadelphia Police Department's Computer-Aided Dispatch (CAD) system where calls are prioritized by seriousness and officers dispatched accordingly. In some cases it may be determined that calls are not a police matter and no officer is dispatched. Calls that result in an officer dispatch, and which at the time of the response the officer deems a credible incident are then classified according to the FBI's Uniform Crime Reporting (UCR) system. Officer initiated activity also may result in inclusion in the INCT. When an officer encounters a situation that may require police response, he or she will contact the CAD. If, after additional information gathering the situation requires police action, the officer incident will be assigned a UCR number. Using the same hierarchical structure of UCR reporting, only the most serious offense is recorded. In sum, the INCT represents a record of incidents to which at least one Philadelphia police officer has responded and at the time of the response has classified the incident according to the FBI's UCR system.

Incidents can be reclassified within five days following the initial classification. For example, an aggravated assault may be reclassified as a homicide if the victim of a shooting passes away as a result of the shooting a few days earlier. For the purposes of the current research, whether an initial non-fatal shooting is later classified a homicide is not of immediate theoretical relevance. It is assumed that police officers will respond swiftly to shooting incidents regardless of the outcome, as these are considered among the most serious of incidents, and thus treated as priorities requiring immediate action by the police. Unlike calls for service which may generate numerous calls in response to a shooting, the INCT collapses these multiple calls and/or a police-initiated response into a single incident. Additionally, the verification and subsequent classification by a police officer of the incident helps ensure that reports of "shots fired" or "person with a gun" are not included in the INCT.

As mentioned above, shooting incidents combine shootings that resulted in criminal homicides and those classified as an aggravated assault or robbery by firearm. For a full list of UCR codes included in this study to measure shootings see Table 1.[2]

[2] The list of UCR codes only represents crimes with a firearm that were eligible for inclusion in the analysis, not all crimes listed were committed during the time-frame of interest.

Table 1: Description of UCR codes utilized in analysis: Shootings

UCR Code	Crime Description
100 series	**Homicide**
111, 112, 113	Criminal homicide by handgun, rifle, shotgun
300 series	**Robbery**
	On the highway
300, 301, 302	By handgun, rifle, shotgun
	Of commercial establishment
310, 311, 312	By handgun, rifle, shotgun
	Cargo theft – hijack of vehicle
316, 317, 318	By handgun, rifle, shotgun
	Of residence
350, 351, 352	By handgun, rifle, shotgun
	Of drug store
320, 321, 322	By handgun, rifle, shotgun
	Of banks/financial institutions
360, 361, 362	By handgun, rifle, shotgun
	Of gas station
330, 331, 332	By handgun, rifle, shotgun
	Of taxicab
370, 371, 372	By handgun, rifle, shotgun
	Of chain store
340, 341, 342	By handgun, rifle, shotgun
	Of taproom, state store or liquor licensed establishment
376, 377, 378	By handgun, rifle, shotgun
	Of grocery story/delicatessen
380, 381, 382	By handgun, rifle, shotgun
	Miscellaneous situations not listed
390, 391, 392	By handgun, rifle, shotgun
400 series	**Aggravated assault**
411, 412, 413	By handgun, rifle, shotgun
	Against a Philadelphia police officer
421, 422, 423	By handgun, rifle, shotgun
	Against a student by school employee
401, 402, 403	By handgun, rifle, shotgun
	Against other law enforcement officers
471, 472, 473	By handgun, rifle, shotgun
	Against a student in a public school
451, 452, 453	By handgun, rifle, shotgun
	Against a teacher or employee in a public school
431, 432, 433	By handgun, rifle, shotgun
	Against a teacher or employee in a private school
441, 442, 443	By handgun, rifle, shotgun
	Against a student in a private school
461, 462, 463	By handgun, rifle, shotgun

In addition to shootings in Philadelphia, the current research also examined arrests for carrying a firearm without a license in Philadelphia. The Pennsylvania Uniform Firearms Act (UFA) introduced in the early 1990s, and subsequently passed in 1995, detailed who may not possess, use, manufacture, control, sell or transfer firearms (Title 18, Chapter 61). More specifically, the Pennsylvania UFA at Section 6106 outlines that a person may not carry a firearm in public, concealed on his or her person and in a vehicle, without a valid and lawfully issued license. In addition to prohibiting those involuntarily committed to a mental institution and those unlawfully in the United States from possessing firearms, the Act lists criminal offenses where a conviction precludes an individual from obtaining a license to possess and carry a firearm (PA UFA).

When an individual breaks at least one of the specific statutes in the UFA, he or she is subject to penalties detailed in the Act. The charges may be referred to as Violations of the Uniform Firearms Act or VUFAs. An individual caught illegally carrying a firearm in a vehicle, or concealed on or about his/her person has committed a felony of the third degree. A person caught possessing a firearm in a vehicle or concealed on or about his/her person who otherwise would be eligible to possess a valid license under chapter 18, and has not committed any other criminal violation, however, commits only a misdemeanor of the first degree (PA UFA Title 18 **§** 6106 (1) & (2)). Data about cases in which defendants were arrested with the lead charge of a VUFA were provided by the Philadelphia Police Department. For a full list of UCR codes included in this study to measure VUFAs see Table 2.

Table 2: Description of UCR codes utilized in analysis: VUFAs

UCR Code	Crime Description
1500 series	**Violation of the Uniform Firearms Act**
	By adult
1501	By handgun
1502	By shotgun
1503	By rifle
1504	Carrying on public street without a license
1505	Possession by prohibited person
1506	All other firearms
	Possession on school property/business
1531	Handgun
1532	Shotgun
1533	Rifle
1534	All other firearms
	By juvenile
1541	Handgun
1542	Shotgun
1543	Rifle
1544	All other firearms

The use of arrest data helps address both questions the current research attempts to answer. The first question pursued in the current research attempts to gauge police responsiveness. Since incidents of arrest are clearly in part a product of police discretion (Tonry, 1995) using VUFAs following a shooting would appear to be an appropriate indicator of police behavior.

Turning attention to the second question, a deterrent effect may be brought about through increases in the perceived likelihood of detection and punishment of criminal activity. It is certainly true that an arrest does not always lead to a conviction and additional sanctions, but the arrest itself arguably constitutes a type of sanction. Further, the arrest follows soonest after a shooting. Survey results of an adult population in three states revealed that most people did not differentiate in terms of the unpleasantness of being arrested, convicted, or incarcerated (Tittle, 1973 as cited in Tittle & Rowe, 1974).

Arrests, therefore, with or even without additional sanctions might function as punishments for and potential deterrents to criminal activity.

Additionally, the use of arrest data may be more desirable than focusing on the certainty and severity of punishment after an arrest. Kohfeld (1983: 460) pointed out potential criminals may know if "arrests occur in their neighborhood" but argued "it is unlikely that criminals know either clearance rates or arrest ratios." The immediacy of a visible arrest is likely to resonate with potential criminals. The arrest creates a heightened threat of apprehension, whereas potential criminals are likely uninformed about the proportion of those arrested who are ultimately convicted, and about the sanctions arrestees receive.[3]

Frequency of shootings and VUFAs across Philadelphia

During the years 2004 to 2007 there were 5,870 total shootings, 1,152 of which resulted in death (homicide) and 4,718 that did not (aggravated assaults and robberies by firearm). During the same period there were 5,687 total VUFAs. [4] Table 3 displays shootings and VUFAs by year.

---

[3] Additionally, firearm arrests might represent a proxy for willingness of people to illegally carry firearms or the general availability of illegal firearms in an area. Therefore, instead of a firearm arrests suppressing shootings, the arrest is an indicator that people are illegally carrying firearms. Kleck (2004: 32) pointed out that, regrettably, "there are no obvious existing proxies that clearly measure firearm availability among criminals." It can be argued that firearm arrests are acceptable indicators of firearm offending in the same way that city-level drug arrests, including possession arrests, have served as valid indictors of drug offending activity (Ousey & Lee, 2002). Although using arrests for illegal firearm carrying as a proxy for illegal firearm carrying has unknown construct validity, illegal drug activity including possession, an analogous behavior, has been measured via arrest data. In the same way that drug-offending activity may be indicated by arrests, Sherman (2004) suggested that arrests for illegal firearm carrying might reflect differences in the number of people illegally carrying firearms. Of course, using an alternative perspective, temporal and spatial variation in arrests may indicate variations in police vigor more than they do variations in illegal firearm carrying (Kurtz et al., 2007). In other words there are questions of construct validity (see Messick, 1995).

[4] Shooting and VUFA totals are calculated from INCT data based on the UCR codes listed in Table 1 and Table 2.

Table 3: Yearly shootings and VUFA totals: 2004 – 2007

	Homicide by firearm	Aggravated assault by firearm	Robbery by firearm	Shooting totals (homicide, aggravated assault, robbery)	VUFA totals
2004	238	935	211	1,384	1,462
2005	282	978	165	1,425	1,427
2006	327	1,132	197	1,656	1,498
2007	305	954	146	1,405	1,300
Totals	1,152	3,999	719	5,870	5,687

Totals based on INCT data provided by the Philadelphia Police Department.

Figure 1 presents the trend of VUFAs and shootings by month across the four years under study. VUFAs ranged from 91 to 160 and shootings ranged from 72 to 177. A visual examination of the trends by month at the city level does not suggest a lagged macro-level correspondence between VUFAs and shootings.

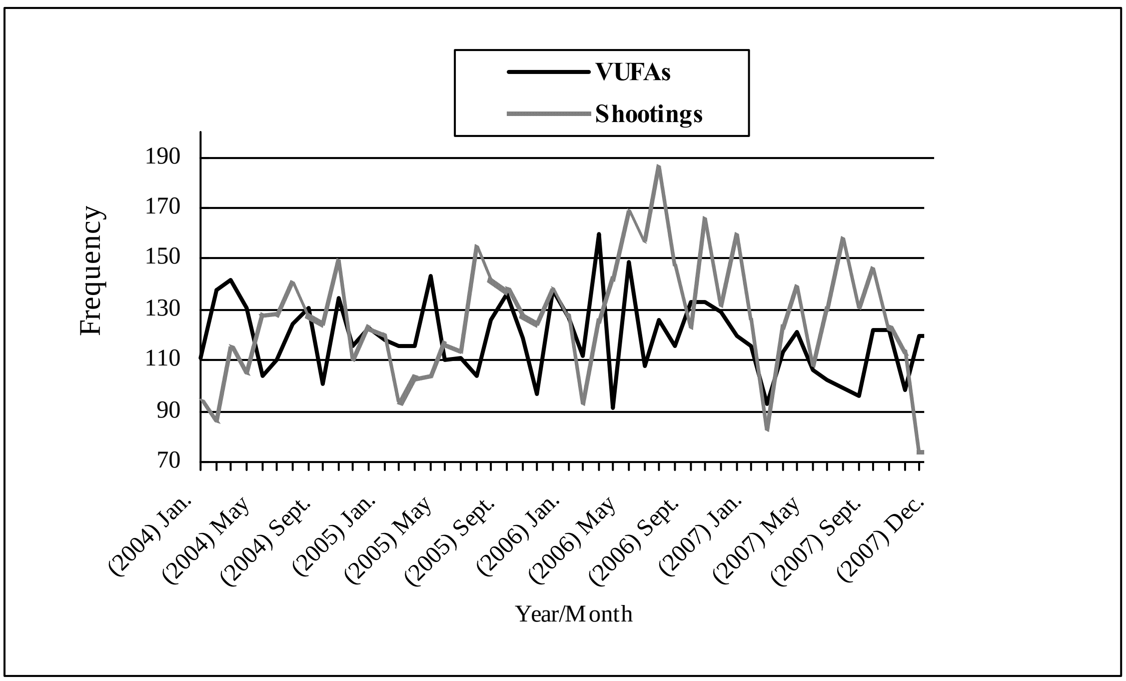


Figure 1: Monthly VUFAs and shootings in Philadelphia: 2004 – 2007

Demographics of sample and Philadelphia residents

Basic demographic characteristics for shooting victims were provided by the Philadelphia Police Department (see Table 4). From 2004 until 2007 African Americans/Blacks made up a majority of shooting victims accounting for 85% of the total; this portion remained consistent over the four-years. Males were far more likely to be victims of shootings than females, comprising about 93% of the shooting victims. The average age of a shootings victim was approximately 27 years old (median 24) and about 86% of the shooting victims were between the ages of the 15 and 39.

Table 4: Demographics of shooting victims in Philadelphia: 2004 – 2007

		2004	**2005**	**2006**	**2007**	**Total**
Philadelphia		1,384	1,425	1,656	1,405	5,870
Race:	Black	1,169 (85%)	1,224 (86%)	1,390 (84%)	1,191 (85%)	4,974 (85%)
	White	199(14%)	180 (13%)	236 (14%)	204 (14%)	819 (14%)
	Other	16 (1%)	21 (1%)	30 (2%)	10 (1%)	77 (1%)
Sex:	Female	73 (5%)	92 (6%)	118 (7%)	106 (8%)	389 (7%)
	Male	1,310 (95%)	1,333 (94%)	1,538 (93%)	1,299 (92%)	5,480 (93%)
Age:	15-39	1,202 (86%)	1,245 (87%)	1,407 (85%)	1,175 (84%)	5,029 (86%)

Note: White includes those identified as White-Hispanic.
INCT data provided by the Philadelphia Police Department.

A comparison of the characteristics of shooting victims to the population of residents in Philadelphia reveals that African Americans/Blacks, males, and individuals 15 - 39 years old are over-represented. Table 5 shows basic demographic characteristics of Philadelphia residents based on census estimates for the years 2004 to 2007.[5]

[5] Census estimates are total resident population estimates including demographic characteristics such as age, sex, race, and Hispanic origin for the nation, states, and counties. The calculations are based on births, deaths, and domestic and international migration and are released yearly after the last decennial census (U.S Census Bureau, 2009).

In Philadelphia during the period 2004 – 2007, approximately 46% of the population was African American/Black and 47% White (White includes those identified as White Hispanic). Census estimates from 2007 indicate that about 39% of people in Philadelphia are White non-Hispanic. The remaining population was primarily Asian and very small percentage American Indian or reporting multiple races (U.S. Census Bureau, 2007). Females slightly outnumbered males and people in the age group 15 to 39 accounted for about 36% of the Philadelphia population estimate. Compared to the overall population of Philadelphia, the distribution of shooting victims were disproportionately African Americans/Blacks, Males, and under 40 year years old. Unfortunately, similar demographic characteristic data for those arrested for illegally carrying a firearm were not provided by the Philadelphia Police Department.

Table 5: Demographics of Philadelphia residents: 2004 – 2007

Philadelphia		**2004**	**2005**	**2006**	**2007**	**Average**
Population total		1,465,476	1,456,350	1,448,394	1,438,962	1,452,298
Race:	Black	45%	46%	46%	46%	46%
	White	48%	47%	47%	47%	47%
	Other	7%	7%	7%	7%	7%
Sex:	Female	54%	53%	53%	53%	53%
	Male	46%	47%	47%	47%	47%
Age:	15-39	37%	36%	36%	36%	36%

Note: White includes those identified as White-Hispanic.
All figures based on census estimates.

Philadelphia police districts and divisions

Before describing the spatial distribution of shootings and VUFAs during the years 2004 to 2007 it may be beneficial to describe briefly the organization of police districts and divisions in Philadelphia as well the distribution of crime across the districts.

As of 2007 there are more than 6,000 officers subdivided across Philadelphia into 25 patrol districts of varying size. Two patrol districts, 77 and 92, cover Philadelphia International Airport and Fairmount Park, the latter a large urban park/green space. Both of these differ significantly from the patrol districts because of land use and the lack of residential population (Philadelphia Police Department, 2007) and were therefore excluded from analyzes.[6]

There is considerable variation in the total land area of police districts as well as in the amount of crime and the socio-demographic characteristics. Focusing first on size of police districts, in Philadelphia they have a mean size of 5.81 square miles, with the smallest police district encompassing only 1.29 squares miles versus the largest police district encompassing 16.33 square miles (Greene, Piquero, Hickman, & Lawton, 2004). On average, smaller police districts are found nearer the center of the city, which tends to be more densely populated, with larger police districts in the less densely populated outer-city areas.

The 23 police districts also are organized into six police divisions. The six police divisions are comprised of three or four police districts each, with districts 77 (Philadelphia International Airport) and 92 (Fairmont Park) excluded from the police divisions. The divisions created by the Philadelphia Police Department are organized geographically with adjacent districts making up the Central (6th, 9th, 22nd, 23rd), East (24th, 25th, 26th), Northeast (2nd, 7th, 8th, 15th), Northwest (5th, 14th, 35th, 39th), South (1st, 3rd, 4th, 17th), and the Southwest (12th, 16th, 18th, 19th) divisions. Figure 2 displays the police districts that structure the police divisions.

---

[6] Less than 50 total shootings and VUFAs occurred in districts 77 and 92 over the four years that data were analyzed.

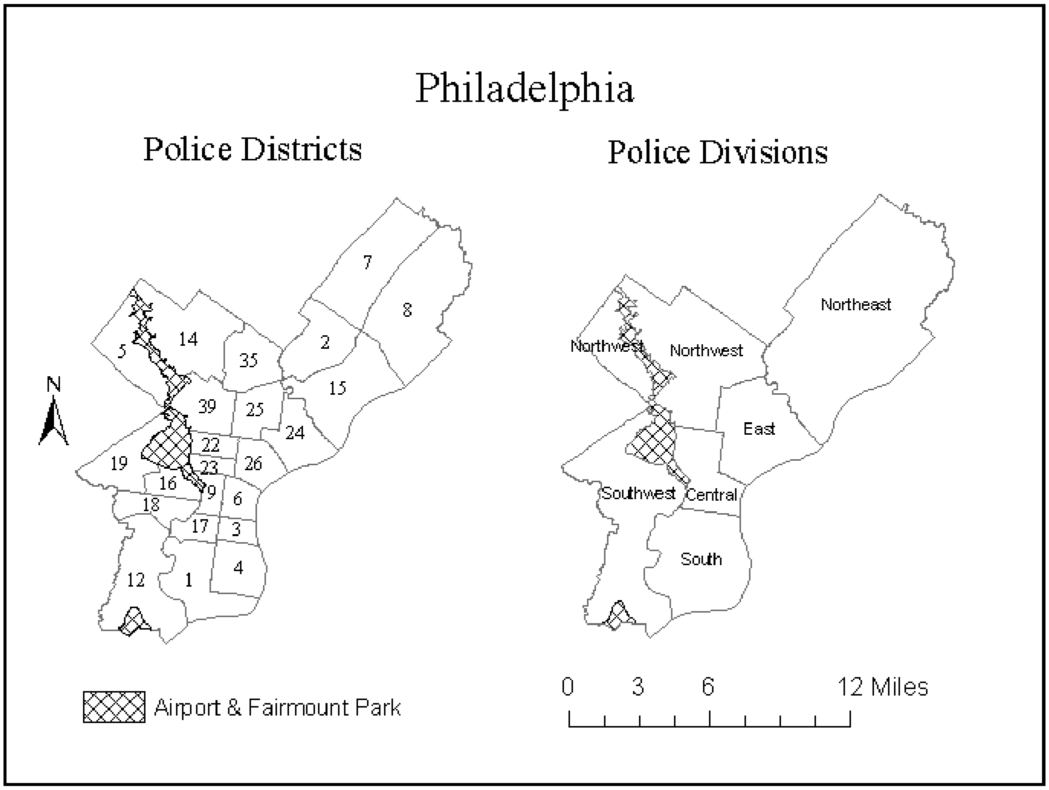


Figure 2: Philadelphia police districts and divisions map

Describing shootings and VUFAs spatially

For the purposes of the current study, shootings were geocoded [assigned (x) and (y) coordinates] to incident locations. VUFAs were geocoded to the street address of the arrest, not the address of the arrestee. It was not possible to distinguish between apartments in the same building. Overall, out of a total of 11,557 shootings and VUFAs recorded by the Philadelphia Police from 2004 to 2007 over 99% (11,511) were successfully geocoded. The geocoding hit rate (successfully geocoded) for shootings and VUFAs was well above the 85% threshold suggested by Ratcliffe (2004) as a first estimate of a minimum reliable geocoding rate. The 46 cases that were not successfully geocoded were primarily the result of the PPD not providing x/y coordinates; and in a small number of cases the x/y coordinates provided could not be geocoded within the city limits of Philadelphia.

Shootings and VUFAs are not randomly distributed within the city. In fact, areas of the city with a high number of shootings also appear to have a high number of VUFAs. Figure 3 shows two-kernel density maps of shootings and VUFAs from 2004 to 2007.

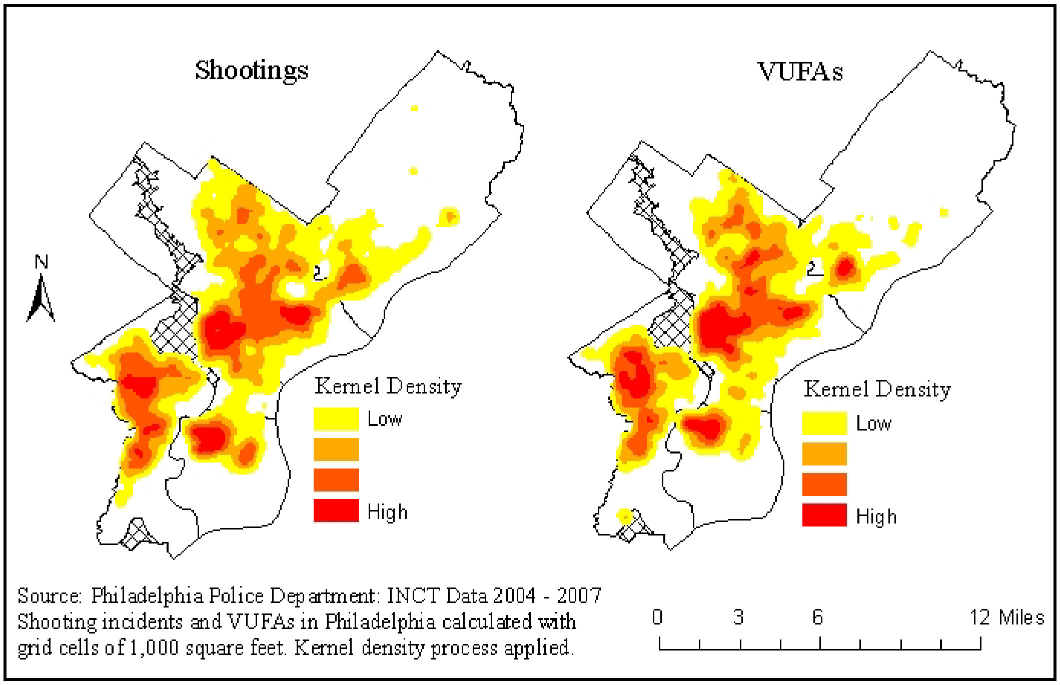


Figure 3: Kernel density map of shootings and VUFAs in Philadelphia 2004 – 2007

The spatial distributions of the shootings and VUFAs are further clarified when examined by divisions.[7] Tables 6 and 7 show the frequency and rate (per 100,000 of residential population ages 15-39) of the shootings and VUFAs by divisions.[8]

[7] There is considerable heterogeneity across police districts that make up the police divisions. Further Klinger (1997) argues that districts organize behavior; therefore, districts might be a more desirable spatial unit than police divisions. However, the infrequency of shootings and VUFAs in some police districts results in the cell frequencies that are too small to perform the analysis. Thus, single districts cannot be used as units of analysis.

[8] A table with shootings and VUFA counts by police districts can be found in Appendix A.

Calculating the population and socio-demographic variables that are encompassed in each police division for the years of interest required the allocation of census estimate data to police districts. The geographies and therefore boundaries of census blocks and police districts do not match uniformly; therefore, census data had to be allocated into police districts.

If a census block falls completely within a police district, 100% of those census data were applied toward calculating police district totals. As mentioned above, however, the boundaries of these different types of geographies may overlap, creating a dilemma concerning how to allocate the census data into police districts. Within a geographic information system the percentage of the census block area that occupies a police district is applied toward the police district. Imagine two adjacent police districts intersect a single census block with 60% of the census block occupying one district and 40% of the census block occupying the other district. To calculate the residential population for the districts, the first district would receive 60% of the population from the census block and the remaining 40% would be applied to the other district. With each district the allocated data are aggregated and the values summed, resulting in socio-demographic variables at the police district level. Police division characteristics are created by combining the district results based on the organization of police divisions.

Generally crime rates are calculated with a type or types of crime as the numerator and the population as the denominator to control for population size. However, a better and more accurate method to control for population size is to consider the population at risk. Since the majority (86%) of shooting victims were between the ages of 15 and 39, the shooting rates are calculated where the numerator is shootings and the denominator is the number of residents (males and females) between the ages of 15 and 39 in each division. Although data were not available regarding characteristics of VUFA arrestees, data regarding cases in which defendants were charged with a VUFA as the most serious charge by the District Attorney's Office were available. Clearly, these VUFA court data only capture a subset of the police incident arrest data because cases may be dropped for a variety of reasons between the arrest and prosecution in court. Nevertheless, the court data allow for a description of individuals prosecuted, information not available with the police arrest data used in this analysis.

These court data showed, similar to the shooting data, the vast majority of defendants charged with a VUFA during the years 2005 - 2007 were younger than 40 years old (Wyant & Taniguchi, 2009). Overall, approximately 90% of defendants in Philadelphia charged with a VUFA as the most serious charge were between the ages of 15 and 39; therefore the total number of VUFAs is treated as the numerator and the number of residents (males and females) between the ages 15 and 39 as the denominator.

Table 6: Frequency and rate per 100,000 (by age 15-39) of shootings by police divisions in Philadelphia: 2004 – 2007

Division		**2004**	**2005**	**2006**	**2007**	**Total**
Central:	count	218	228	276	218	940
	rate	383	411	515	416	430
East:	count	255	264	287	277	1,083
	rate	345	353	379	364	360
Northeast:	count	90	96	158	104	448
	rate	71	77	130	86	91
Northwest:	count	293	284	290	275	1,142
	rate	260	255	263	252	258
South:	count	131	171	202	150	654
	rate	244	323	390	292	312
Southwest:	count	397	382	443	381	1,603
	rate	354	344	401	348	362
Philadelphia:	count	1,384	1,425	1,656	1,405	5,870
	rate	258	269	316	271	278

INCT data provided by the Philadelphia Police Department

Table 7: Frequency and rate per 100,000 (by age 15-39) of VUFAs by police divisions in Philadelphia: 2004 – 2007

Division		**2004**	**2005**	**2006**	**2007**	**Total**
Central:	count	262	247	230	192	931
	rate	460	434	404	337	426
East:	count	215	237	246	222	920
	rate	291	320	332	300	306
Northeast:	count	111	130	159	119	519
	rate	88	103	126	94	105
Northwest:	count	338	284	327	309	1,258
	rate	300	252	291	275	284
South:	count	131	172	173	99	575
	rate	244	320	322	184	274
Southwest:	count	405	357	363	359	1,484
	rate	361	318	323	320	335
Philadelphia:	count	1,462	1,427	1,498	1,300	5,687
	rate	273	266	280	243	270

INCT data provided by the Philadelphia Police Department

There was some variation among the frequency and rate of shootings and VUFAs across the police divisions. Overall, fairly consistently over the four-year period the same divisions that were characterized by either highest or lowest number of shootings were also characterized by the highest or lowest number of VUFAs. Of the six police divisions, the Northeast Police Division ranked the lowest in terms of the number and rate of shootings (91 per 100,000 population 15 – 39 year olds) and VUFAs (105 per 100,000 population 15 – 39 year olds). These rates were considerably lower than the rate over four-years in Philadelphia of 278 for shootings and 270 for VUFAs (per 100,000 population 15 – 39 year olds. In some cases those divisions with the highest frequencies did not also have the highest rates. The greatest number of both shootings and VUFAs occurred in the Southwest Police Division, but taking into account the number of 15 – 39 years-olds, the Central Police Division had the highest rate of shootings with 430 per 100,000 population 15 – 39 year olds as well the highest rate of VUFAs with a rate of 426 per 100,000 population 15 – 39 year olds relative to the other police divisions.

Status and violent crime by police division

As mentioned above, police responses to criminal activity and criminal responses to arrests may vary under different community conditions (Klinger, 1997; Kohfeld & Sprague, 1990; Smith, 1986). A very basic rendering of Klinger's model posits that police officers in high deviance and high crime police districts are less vigorous in their enforcement of the law. Although the current research does not conduct a direct test of Klinger's ecological theory of police response or directly test whether under varying community conditions, the likelihood of police stopping an individual is enhanced or attenuated depending on the neighborhood in which the interaction takes place. His view highlights that police officers patrol both people and places. Therefore, additional analyses are conducted separately by the six Philadelphia Police divisions. In addition to the frequency and rate of shootings and VUFAs for the years 2004 to 2007, Table 8 provides contextual information in the form of a socio-economic status indicator and a violent crime rate variable for the six police divisions in Philadelphia.

The status indicator was based on 2000 census block group data that were allocated into police districts in the same process described above.[9] The status index (Cronbach's alpha = 0.90) was created from the average z-score of four-items: median household income, percent of people with a four-year college degree or better, median home value, and percent of people above the poverty line. Higher values indicated greater status. The violent crime rate indicator was created using Philadelphia Police Department violent crime data from January 2001 through June 2002. Homicides, rapes, robberies, and aggravated assaults were annualized, summed, and converted into one rate per 100,000 population using 2000 census population figures (Lawton, Taylor, & Luongo, 2005).

[9] In order to create the police division totals for each indicator, within each division the population for each district was divided by the overall division population it resided in. The resulting percentage was then multiplied by the previously calculated district score for each indicator. Within each division the newly calculated scores were summed to generate the division total.

Table 8: Status, violent crime rate, shootings, and VUFAs by Philadelphia police divisions

Division	**Status**	**Violent Crime**	**Shootings (freq./rate)**	**VUFAs (freq./rate)**
Central	0.46	2253.08	940/430	931/426
East	-3.00	2333.92	1,083/360	920/306
Northeast	3.13	634.58	448/91	519/105
Northwest	1.69	1279.48	1,142/258	1,258/284
South	-0.48	1438.93	654/312	575/274
Southwest	-1.81	1625.06	1,603/362	1,484/335
Philadelphia	.061	1411.44	5,870/278	5,687/270

Status indicator based on 2000 Census data. Violent crime indicator based on annualized homicides, sexual assaults, robberies, and aggravated assaults from 1/1/2001 – 6/30/2002. Shootings and VUFA frequencies based on INCT totals from 2004 to 2007. Shootings and VUFA rates are per 100,000 (by age 15-39) based on Census estimates 2004 to 2007.

Briefly focusing on differences in status across police divisions the Northeast Police Division (3.13) had the highest status total followed by the Northwest Police Division (1.69) and Central Police Division (0.46). The remaining three police divisions had negative status scores, the East Police Division (-3.00) posted the lowest status score by a considerable amount followed by the Southwest Police Division (-1.81) and the South Police Division (-0.48). Turning attention to violent crime, the violent crime rates in the Northwest, South, and Southwest Divisions were generally close to the Philadelphia average of 1411.44. The Central Division (2253.08) and East Division (2333.92) had the highest violent crime rates and the Northeast Division (634.58) the lowest. Figure 4 presents quantiles of shootings, VUFA, violent crime and status by police division to illustrate the general spatial uniformity of these four variables by police division.

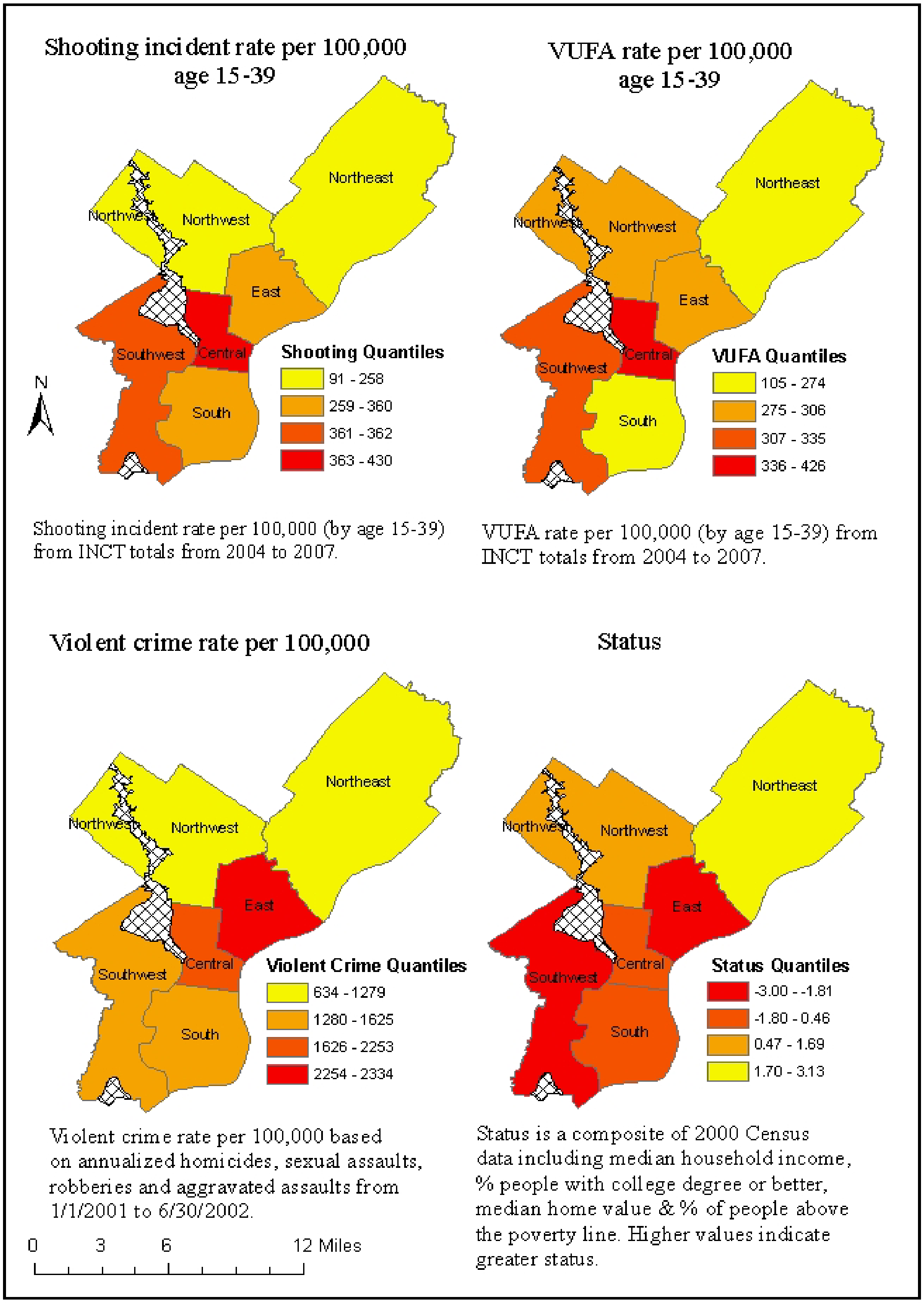


Figure 4: Spatial distribution of shootings, VUFAs, violent crime rate, and status by police division

Taken as a whole, there were clear disparities between police divisions. The Northeast Division had the lowest rate of shootings, VUFAs, violent crime and the highest score on status. The East Police Division had the lowest status score and highest violent crime rate, and the Central Police Division had the highest rate of shootings and VUFAs. The Southwest Police Division had the third highest violent crime rate and second highest shooting and VUFA rates. The Northwest and South, were closer to the averages in Philadelphia for shooting, VUFA, and violent crime rates, and for status (see Table 8 above for a summary).

Analytic method

A spatio-temporal clustering technique is used to determine whether the number of shootings and VUFAs are associated in space and time at a micro-scale, or if shootings and VUFAs are independent of each other. Stated differently, the current investigative method is a new approach to determining whether shootings link to arrests for illegal firearm carrying at the scales of days and hundreds of feet.

The data required for the current study consist of the date and location (x/y coordinates) of both VUFAs and shootings. Using the standard projected coordinate system for South Pennsylvania (NAD 1983 State Plane Pennsylvania South FIPS 3702 Feet), the locations of each shooting and VUFA were recorded in feet to best facilitate the calculation of Manhattan distances (Ratcliffe & Rengert, 2008). Manhattan distances most precisely reflect the actual distance traveled by urban residents by taking into account the traditional grid layout of most streets, whereas Euclidean distances (also known as “crow flies” distances) simply measure the shortest distance between two points (Chainey & Ratcliffe, 2005).

Knox method

The method used in this study draws from the Knox close pair method, originally used to study the communicability of disease. The Knox method identifies whether an excess of observed event pairs occur more closely in space and time than one would anticipate based on chance (Townsley, Homel, & Chaseling, 2003). Even though the Knox method was originally used to study contagion via micro-organisms, processes with both biological and social components, behavioral or social phenomena such as burglaries or shootings may follow spatio-temporal patterns which are analogous to communicable disease patterns (Jones & Jones, 2000). When used to study crime, researchers (e.g. Johnson & Bowers, 2004a, 2004b; Ratcliffe & Rengert, 2008, Townsley, Homel, & Chaseling, 2003) have noted the primary benefit of using the Knox method is its ability to test for clustering of events in both space *and* time.

The problem is figuring which pairs of crimes are more likely to have related dynamics. Spatial but not temporal clustering may simply reflect ongoing crime levels. Temporal but not spatial clustering may reflect broadly increasing crime rates. Such clustering of crime pairs either in time or in space can be compared to the expected clustering if the patterns were driven solely by chance rather than by related dynamics. Thus, crime pairs must be significantly different from what is expected by chance in space *and* time to suggest they are in some way related, otherwise, concentrations in time *or* space may suggest high levels of crime in small areas or changes in crime levels produced for a variety of reasons (Townsley, Homel, & Chaseling, 2003).

The Knox close-pair method, a modified version of which is used here, was first used to identify space-time clusters of childhood leukemia. In a study of the epidemiology of childhood leukemia, Knox (1964) observed that cases of childhood leukemia clustered in space *and* time. He also noted, however, inherent methodological and conceptual problems. He concluded that an accurate analysis of clusters in space and time required a:

> separate examination for the three components of epidemicity: (a) concentration in space, over the whole of the time of the study; (b) concentrations in time over the whole of the area of the study; (c) interactions between space and time concentrations (17).

In order to identify interactions between space and time clusters, Knox proposed an examination of all possible pairs of childhood leukemia cases to determine whether small physical distances were positively associated with short time intervals between pairs of events (Knox, 1964).

Knox (1964), in order to identify these interactions between space and time, paired each childhood leukemia case with every other childhood leukemia case thereby N cases produce N(N – 1)/2 distinct pairs (Townsley, Homel, & Chaseling, 2003). Spatial and temporal distances between all possible pairs were aggregated into a contingency table where rows and columns listed outlining distances and temporal intervals between each case of childhood leukemia. Examining 185 cases of childhood leukemia in the North of England over a 10-year period, Knox considered cases in a pair close in space if the two events were less than one kilometer apart. Cases in a pair were considered close in time if they occurred within 60 days of each other (Knox, 1964). Next, the number of pairs of childhood leukemia cases considered close spatially and temporally were compared to the expected count if the pairs had been distributed randomly in both space and time. Case pairs exceeded what would be expected under the assumption of random spatio-temporal processes generating random patterns. The non-random arrangements, he concluded, arose from contagion processes (Knox, 1964).

Originally the Knox method called for a comparison of the observed values from each cell of the contingency table with the adjusted residual value for each cell. Each of the latter captured the cell's (observed – expected) departure, using marginal row and column numbers to calculate expected frequencies, as is done in traditional chi-squared calculations. Ratcliffe and Rengert (2008) pointed out, however, that since the Knox method assesses the significance of the departure of observed values in the contingency table from the expected values conditional on the marginal totals, it possibly violates an assumption of independence of observations. Since each crime event is measured in terms of space and time from every other crime event, each event pair is not independent of each other event pair.

To combat the potential issue of a lack of independence, researchers (see, Johnson & Bowers, 2004a, 2004b; Ratcliffe & Rengert, 2008; Townsley, Homel, & Chaseling, 2003) built on the work of Besag and Diggle (1977) who examined colonies of Kittiwakes, a coastal breeding bird. While maintaining the values of the event location for their study (warehouse window ledges), Besag and Diggle (1977) used a Monte Carlo simulation to shuffle the date on which each event occurred. They randomly shuffled the dates repeatedly to create a number of contingency tables. For each cell, these shuffles created a distribution of expected values. The observed value for each cell could thus be placed on the distribution of expected values for that cell, generating both an expected ratio (observed values/mean of expected values), and a pseudo-probability with the latter based on the placement of the observed value on the distribution of expected values.

To illustrate a contingency table and the incorporation of the Monte Carlo simulation, imagine over a one-year time period a small city has recorded 84 residential burglaries along with the date and location of each of those burglaries. Although Knox studied the transmission of disease, the same principles in constructing a contingency table can and have been applied in the field of criminal justice. For example, a researcher might hypothesize that burglaries will cluster in space and time since offenders after a successful burglary may soon return to houses near their initial burglary incident since they may have scrutinized surrounding dwellings and feel confident they will be successful again (Townsley, Homel, & Chaseling, 2003). Using the aforementioned formula $N(N - 1)/2$, 84 residential burglaries would produce 3,486 distinct pairs. The geographic distance and the amount of time elapsed between each pair of events is calculated and placed into the contingency table.

The contingency table will summarize how many pairs of residential burglaries occurred within various spatial and temporal bandwidths. To examine all pairs closer than 5,000 feet (almost one mile) and one year apart a researcher might select spatial increments of 500 feet and temporal increments of 60 days (approximately two months). Ultimately the temporal and spatial bandwidths are at the researchers' discretion (Ratcliffe & Rengert, 2008; Townsley, Homel, & Chaseling, 2003) informed, of course, by his/her interpretation of relevant theory and research findings. Using a space dimension of 500 feet and 60 day intervals would result in a contingency table with six columns and 10 rows. The range of spatial and temporal increments used will allow for a sensitive analysis of the hypothesis investigated.

Once the contingency table is populated, the pairs of residential burglaries are compared to the number that would be expected under the null-hypothesis. To reiterate, the null-hypothesis is what is expected if the timing of the burglaries were distributed randomly across the columns in the contingency table. To generate a contingency table where the location and timing of burglaries are independent, the date on which the burglaries occurred is randomized across events.

To randomize the timing of burglaries a Monte Carlo approach is used. Leaving the space distribution in place, the Monte Carlo simulation generates a new random distribution of times for the burglaries. Stated differently, the dates on which burglaries occurred are randomly rearranged. Each simulation will regenerate the amount of time elapsed between each pair of burglaries. This process creates a new expected contingency table. These expected values are ones where the elapsed time between event pairs reflects no temporal association. This process, one in which the burglary times are randomly shuffled, is repeated a number of times; the exact number of times is at the researchers' discretion but 99 permutations are common. By conducting 99 simulations, where in each simulation the dates on which the residential burglaries occurred are randomly rearranged while preserving the distance distribution across event pairs, 99 new contingency tables with only expected values are created.

The 99 expected values generated in each space-time cell should roughly follow a normal distribution. Next, the observed value in each space-time cell can then be positioned on that cell's distribution of randomized expected values. Where the observed pair count is placed on the cumulative probability distribution generated by the expected values in that cell determines its pseudo-probability. The ratio of the observed pair count in each cell to the mean expected pair count creates the observed/expected Knox ratio. One is determining whether the number of observed event pairs in a specific space-time cell exceeds or under-represents the average expected pair count and by how much. This is repeated for all cells across the entire spatial and temporal ranges.

Based on the number of times that the observed pair count of burglaries exceeds the expected pair count for each specific cell an estimate of statistical significance can be calculated. The number of times that the observed number of burglaries surpasses the numbers generated by the Monte Carlo simulation can be calculated into a pseudo *P*-value. For example, if the observed number of burglaries was 189 in the cell based on 1 to < 500 feet from the initiating event and less than 60 days between the first and second event, and 95 of the 99 Monte Carlo simulation runs generated a value below 189 (the observed value) one could conclude that the chances of getting an observed pair count this high or higher was < .05 (pseudo $P < 4/99$). If none of the expected values generated from the 99 permutations exceeded 189 (the observed value) the result would be a pseudo *P*-value of 0.01. Where the observed value exceeded the expected values at least 95% of the time, frequencies observed were not likely to occur under the null hypothesis of no spatio-temporal clustering (Johnson, Summers, & Pease, 2009).

Additionally, if one wishes to focus on the rows or columns of a table, rather than just individual cells, statistical significance of the observed value for each spatial or temporal dimension can be calculated as $P = 1 - n_e/(n_s+1)$, where n_e represents the number of times that the expected values were greater than the observed and n_s represents the number of permutations (Ratcliffe & Rengert, 2008).

Lastly, an effect size can be calculated by dividing the observed value from a space-time cell by the mean of the expected values from that same space-time cell. For example, the observed value of 189 from the 1 to < 500 feet and 60 days and less cell is divided by the mean of the expected values derived from the 99 permutations. A mean expected value of 110 would indicate that 1.7 times as many events occurred in the 1 to < 500 feet and less than 60 days cell than was expected under a random distribution. The effect size associated with the clustering for this cell would be +.7 or 70 percent.

Analysis plan

Using much of the same logic and methods described above, the current research explores whether there is evidence of space-time clustering of shootings and VUFAs. Although many of the methods are similar, the current research differs significantly from past work on disease transmission or repeat/near-repeat victimization by focusing on two different phenomena, shootings and VUFAs, instead of a single type of event such as cases of childhood leukemia or residential burglaries.

The data are analyzed using a C#.NET program originally written by Dr. Jerry H. Ratcliffe to specifically compute multiple simulations of the expected values, and modified for this project. Using C# programming language to create an executable program for Windows, the program created to examine space-time relationships between a single type of phenomenon was modified to read the data and create an observed matrix of space-time associations among two different types of phenomena, in this case shootings and VUFAs.

As mentioned above, originally the program was developed to recognize only one type of event and calculate space-time intervals between these single events to uncover patterns where events were over-represented. Additionally, the distance and the amount of time elapsed between each pair of events was calculated regardless of the sequence of the events. In order to conduct the current research in C#.NET, an array was added to the original program to differentiate between the two different types of events, either a shooting or a VUFA.

Next, the file reader was modified to account for the extra field (the event type). A radio button was added to the dialog box so the user can specify the direction of the relationship. Either a shooting can precede later VUFAs or a VUFA can precede later shootings. Selecting the direction signifies to the program to calculate the distances and elapsed times focusing only on VUFAs that occurred after a shooting, or on shootings that occurred after a VUFA. When it is expected that a shooting influences the likelihood of later VUFAs, event pairs between each shooting and prior VUFAs are not constructed. Likewise, for question number two where the effect of a VUFA arrest on later shootings are considered, event pairs between a VUFA and prior shootings are not constructed.[10] Once the modified program correctly identifies the direction of the events and measures and records the event pairs of interest (depending on the direction specified), the original calculation methods apply.[11]

---

[10] One might expect shootings and VUFAs to covary, that is to say illegal firearm arrests and shootings may increase and decrease in tandem spatially and temporally. Considerable research has found that assaultive violence and firearms spread together in human populations (Blumstein, 1995, Blumstein & Cork, 1996; Boyum & Kleiman, 1995; Cork, 1999; Loftin 1986; Van Kammen & Loeber, 1994). The current study acknowledges this potential but testing for simultaneous occurrences may confound the two separate trends; therefore, shootings-arrest links are tested separately.

[11] All coding modifications to the original program written to examine space-time relationships between a single type of phenomena were documented and the final code written specifically for this analysis was reviewed by Dr. Jerry H. Ratcliffe (the writer/programmer of the original code) to help ensure the integrity of the coding modifications. Additionally, a small sample of the data (15 incidents) was analyzed via the modified program. Using a small data set allowed for an easy assessment of whether the data were loaded properly. Once it was determined the data were loaded properly, the modified program was run with the sample data set. The results were checked manually to ensure the modified program was reliably and

Once the data are sorted in ascending order beginning with earliest events and read into the program, the spatial and temporal distances between the cases for each pair are recorded. A matrix is created and pair counts (either a shooting and later VUFAs or a VUFA and later shootings) are aggregated and placed in the matrix based on the distance bands and temporal bands, resulting in a table displaying the counts of event pairs observed.

For both questions, the distance parameter is 400 feet and the time parameter two days. The 400-feet increments were selected because the Philadelphia streetscape supports using bandwidths of 400 feet, as many city blocks are approximately 400 feet and street blocks serve as important settings for both crime (Taylor, Gottfredson, & Bower, 1984) and reactions to crime (Taylor, 1997). Turning attention to the selection of the temporal parameters, relatively small time increments (two days) were used as criminal activity should prompt a fast response from police (Kohfeld & Sprague, 1990). More specifically, the Philadelphia Police Department, like other police departments, assigns priority numbers to incidents, with the first priority incident being dispatched and responded to first. Calls to assist other officers and then crimes in progress (such as shootings, and homicides in particular) are considered very serious incidents, and thus treated as priorities requiring immediate action by the police (Philadelphia Police Department, 2008). Small time increments would also appear prudent to address the

---

accurately measuring the distance and the amount of time elapsed between events. Lastly, results were manually reviewed to make certain that distance/time was measured from firearms arrests that occurred after a shooting and vice versa depending on which direction the researcher indicated.

second question because offenders consider the "immediate characteristics of the situation" when contemplating whether to commit a crime (Cusson, 1993: 60).[12]

The 400 feet/two-day increments were extended up to 2,800 feet (approximately one-half mile) and up to 14 days apart. The remaining event pairs with distance and temporal periods greater than 2,800 feet and 14 days are calculated and aggregated in the final column or row.[13] This results in a contingency table with 8 columns and 8 rows. Finer increments are not feasible because the resulting cell frequencies are too small.

Given the above discussions about how police operate, and about ecological deterrence, of most interest in these analyses will be cells reflecting just a few days, say up to about a week, and reflecting just two or three blocks, say up to about 1200 feet.

Once the contingency table is developed and populated, the cell counts are contrasted with the null-hypothesis condition (the expected values based on a random distribution). The current study uses the same Monte Carlo approach described above to perform repeated simulations of the actual study data. Again, the Monte Carlo simulation keeps the event location fixed to generate tables that have the same marginal distance totals for pairs as the table under consideration to create an expected distribution in the absence of space-time clustering (Ratcliffe & Rengert, 2008).

Each of the two main questions addressed here concentrates on different subsets of event pairs. As different subsets of the same data set are used in the analyses, there is

---

[12] In order to determine whether the patterns observed were dependent on the cut points chosen additional analyses were conducted (not shown) where the spatial and temporal periods were lengthened and shortened.

[13] Research has noted that as the distance intervals increase so does the area covered. Stated differently, a distance of 400 feet from an event encompasses a much smaller area than a distance of 800 feet which encompasses an area more than twice as big as the first interval (Rengert, Piquero, & Jones, 1999; Turner, 1969). The equal radius buffers result in different areas with larger areas allowing more opportunities for events to be present. This potential limitation is not problematic as the Monte Carlo simulation takes into account the base rate differences between areas that shape the observed counts by distance.

potentially an overlap in the two sets of events pairs, that is, the analyses might not be completely independent. Although Kohfled and Sprague (1990) argue police and criminal behavior are “not simultaneously interactive if measured on sufficiently fine temporal and spatial scales” (112), it is difficult to gauge the existence and/or the extent of an overlap between the two sets of pairs examined in these two different analyses.

The analyses described here are conducted for each question across the entire city as well as separately by each of the six city police divisions to explore possible variation in the patterns uncovered across different sections of the city.[14] The different social conditions found in each division might influence whether or not, and to what degree, police actions influence offender behavior (Kohfeld & Sprague, 1990).[15] Relationships may depend on the violence level or relative SES of that part of the city. Police may view those living in high crime and/or low relative SES areas as symbolic assailants (Terrill & Reisig, 2003), thus police may feel the need to stop a large number of individuals and uncover illegal firearms in the process. At the same time, police officers working in high crime and/or low relative SES areas might be less willing (or able, due to other more serious crimes) to expend time engaging in proactive police work that may lead to detecting those who are illegally carrying firearms (Klinger, 1997). Of course the volume of event pairs and their spatio-temporal distributions vary as well across divisions. If the

[14] Conducting analyses by police divisions potentially introduces the analytic concern of edge effects but performing only a city level analysis may mask variation occurring in different parts of the city. Hence, analyses are conducted across both the entire city and by police divisions; additionally the findings from these two approaches are contrasted.

[15] The ecological heterogeneity across police divisions was noted above. The portion of the analysis that examines whether or not results are replicated across differing parts of the city is in part dependent on the construction of the areas under study. Although the use of different boundaries within the city may result in different findings, the use of very small boundaries is not feasible as the cell frequencies are not large enough to conduct the analysis. Additionally, the use of an event-centered conception of location and multiple micro-spatial increments within these given boundaries may best capture underlying dynamics that may influence offender and police behavior, thus assuaging this concern.

volume is low, expected values become low also. Testing both questions across the city as well as the six police divisions results in a total of 14 2 by 2 contingency tables, seven related to each question.

To test each question a different set of event pairs are produced. For question one, which explores whether a shooting generates a police response in the form of an arrest of those illegally carrying a firearm in the period soon after and in nearby locations, each shooting is paired with VUFAs that occurred after a shooting (see Figure 5), up to the maxima of the time and space intervals. The first question seeks to uncover patterns where the observed values of arrests are *greater* than the expected values. An effect size above one indicates an over-representation of VUFAs in the Knox pairs, relative to expected values based on chance.

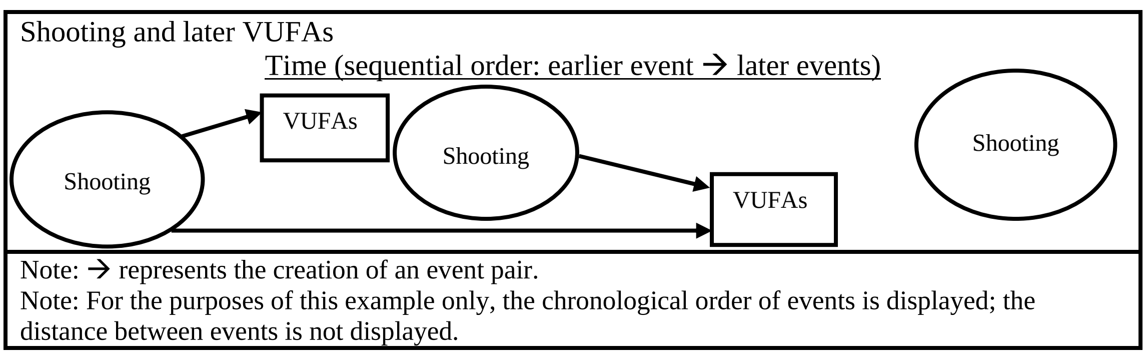
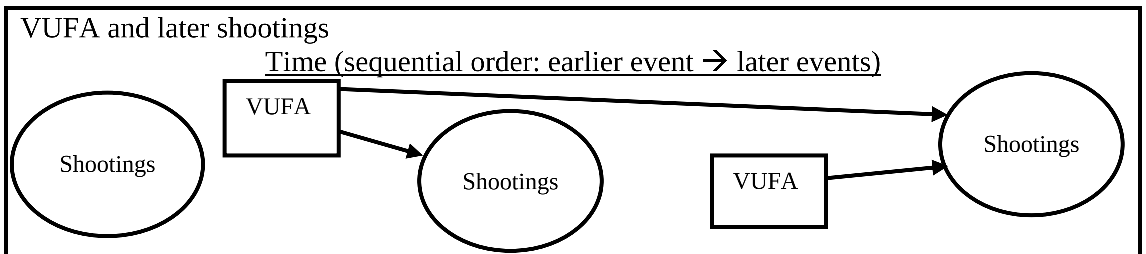


Figure 5: Initiating event question # 1

For question number two, investigating links between an earlier VUFA arrest and later shootings, arrests are the initiating event (see Figure 6). Contrary to the prior work in the near-repeat framework, a portion of the current work seeks to uncover patterns where the observed values of shootings will be *lower* than the expected values. The same procedure for constructing excepted cell pair frequencies is followed, allowing the construction of the same observed/expected ratios as in the analysis for question one. A finding that the observed number of shootings are less than the expected count every time results in a pseudo *P*-value of 0.01. An effect size below one indicates that observed shootings are less likely to occur than expected under a random distribution.



Note: → represents the creation of an event pair.
Note: For the purposes of this example only, the chronological order of events is displayed; the distance between events is not displayed.

Figure 6: Initiating event question # 2

CHAPTER 4:

RESULTS

Results and a brief discussion are presented for the first question examining whether a shooting is associated with nearby firearm arrests in the period immediately following, for the entire city of Philadelphia and then by each of the six police divisions. Next, results and a brief discussion are presented for the second question examining whether a firearm arrest links to later drops in shootings nearby in Philadelphia overall and then again by each of the six police divisions. For each question a more in depth interpretation of the results is presented in the following chapter (Chapter 5: Discussion).

Results for question # 1

Event pairs consist of cases where a shooting preceded a VUFA, making the shooting the initiating event. Therefore, the distance and the amount of time elapsed was calculated only for VUFAs that occurred after a shooting.

Philadelphia (question # 1)

Table 9 shows results when the earlier shootings and later VUFA pairs were analyzed for the whole city and years 2004 – 2007. The first rows of the tables display the results for VUFAs that occurred after a shooting within 1 – 400 feet. The following rows are divided into increments of 400 feet with the final rows displaying pairs that occurred over 2,800 feet from each other, or about half of a mile. The columns are partitioned into increments of two days and up to 14 days with the final column showing pairs that occurred more than two weeks apart. For tables presenting Knox ratios (observed values over the mean expected value), values in bold with a single asterisk indicate values where the pseudo *P*-value is less than 0.05 and those with two asterisks indicate a pseudo *P*-value less than or equal to 0.01. A table for Philadelphia displaying the pseudo *P*-values by each cell can be found in Appendix B and pseudo *P*-values that are less than 0.05 are in bold.

Given Maltz's (1994) discussion of the potential pitfalls of focusing only on statistical significance, observations on the general patterning of the ratios are offered first. The general pattern in Philadelphia of the Knox ratios in the top left of the table -- the three closest periods and distances -- are theoretically the most relevant.

A clear, spatially decreasing monotonic pattern appears in the first two days after and ranging up to about a fifth of a mile away (observed over expected values = 3.61, 1.55, 1.21). Although not as large as the Knox ratio in the top of the first period after the incident, the Knox ratios in the third column for the period 5 to 6 days after are greatest for the two closest distances, as was seen for the 0 to 2 day period, and tend to drop as one moves away in space.

Taken as a whole, the closest Knox ratios in the 0 to 6 day range: are above one; are highest closest in space and time to the initiating event; and for the four closest distance intervals usually show temporal decay across the first two periods. A clear distance decay effect up to about a fifth of a mile appears only in the period immediately following the initiating event.

Pseudo *P*-values in many cells were below the 0.05 in the theoretically predicted direction near the initiating event and soon after. Significance was most clearly patterned in the immediate police response, with significantly elevated ratios up to about a quarter of a mile away. In the 1 – 400 feet and 0 to 2 days cell the number of VUFAs was over two-and-half (Knox ratio = 3.61) times greater than would be expected under a random distribution hypothesis; VUFAs following a shooting were significantly over-represented in the 401 – 800 feet/0 to 2 days cell by 55 percent (Knox ratio = 1.55) and in the 801 – 1200 feet/0 to 2 days cell by 21 percent (Knox ratio = 1.21). Significantly elevated ratios also appeared for 801-1200 feet/3 to 4 days after cell (elevated 30 percent) and the 401-800 feet/5 to 6 days cell (elevated 40 percent).

Table 9: Philadelphia observed over mean expected frequencies
Shooting and later VUFAs: 2004 – 2007

	Days between events							
Distance between events	0 to 2 days	3 to 4 days	5 to 6 days	7 to 8 days	9 to 10 days	11 to 12 days	13 to 14 days	15 + days
1-400 ft	**3.61****	1.03	1.30	1.04	1.06	1.47	1.04	0.99
401-800 ft	**1.55****	1.03	**1.40****	1.20	1.19	**1.44***	0.96	1.00
801-1200 ft	**1.21***	**1.30***	1.16	0.95	1.12	1.08	1.12	1.00
1201-1600 ft	**1.41****	1.01	1.14	1.10	0.68	**1.25****	1.02	1.00
1601-2000 ft	1.14	1.01	**1.31****	1.01	1.16	1.11	0.95	1.00
2001-2400 ft	1.10	**1.22***	1.08	**1.17***	1.02	1.03	1.14	1.00
2401-2800 ft	1.09	1.12	**1.18***	1.08	1.02	0.82	0.99	1.00
2801 ft +	**1.01****	**1.05****	**1.06****	**1.02***	**1.03****	**1.06****	**1.04****	1.00

Events = 11,511 (shooting n = 5,859; VUFA n = 5,652); Event pairs = 15,988,091
***$p < .05$; **$p \leq .01$**

The immediate response shown after the initiating event, and its clear spatial gradient, together suggest an immediate and geographically targeted police response to a shooting. As theoretically anticipated, the observed patterns suggest that after a shooting police respond swiftly and most noticeably in the locations closest to the shooting. There are also more arrests immediately following but in locations somewhat further away, and later arrests also somewhat further away. For the latter, perhaps police remain near the location of the shooting, resulting in additional firearm arrests.

Additional analyses were conducted to determine if the patterns observed in Philadelphia at large were replicated across the six police divisions. The varying ecological conditions may influence the manner and speed with which police respond to shootings. Of course, the varying levels of shootings across divisions also constrain spatio-temporal patterns.

Key features of the citywide pattern can be separated into the following:

a) a lower Knox ratio 3 to 4 days after the initiating response as compared to 0 to 2 days after, for the two nearest buffers (temporal decay close by);

b) an immediate response that was weaker one buffer away than in the nearest buffer (immediate spatial decay in closest locations);

c) a generally (albeit not necessarily perfect) monotonic decline in responsiveness during the first period up to about a quarter mile away (longer range spatial decay); and

d) the highest Knox ratio appearing closest to and immediately following the initiating event (targeting).

Of interest will be seeing which key features of the citywide pattern emerge, albeit perhaps only partially, in these different divisions.

Central Police Division (question # 1)

Results from Philadelphia (see Table 10) were partially replicated in the Central Police Division (pseudo *P*-values can be found in Appendix C). As described above, the Central Police Division was characterized by a violent crime rate about 60% greater than that of Philadelphia as a whole but a status score very similar to that of Philadelphia overall.

As anticipated in the top left of the Knox table, there is a significant quick and spatially targeted over-representation of VUFAs in the 1 – 1200 feet/0 to 2 days cells following a shooting. Also, this over-representation of the VUFAs declines spatially and to some extent temporally in the immediate aftermath of a shooting. Unlike Philadelphia overall, the over-representation did not extend beyond two days as the Knox ratios in the second column were below one and those in the third column were narrowly above one. An examination of the full tables reveals that a number of Knox ratios in the 2801+ feet cells are above one and statistically significant; however, it is unlikely these effects are related to a single shooting that occurred at a minimum of approximately one-half of a mile away. Potential explanations for these significant, yet not theoretically expected, findings are discussed in the ensuing chapter.

Table 10: Central Police Division observed over mean expected frequencies
Shooting and later VUFAs: 2004 – 2007

	Days between events							
Distance between events	0 to 2 days	3 to 4 days	5 to 6 days	7 to 8 days	9 to 10 days	11 to 12 days	13 to 14 days	15 + days
1-400 ft	**2.45****	0.64	1.11	0.23	0.88	1.39	0.51	1.00
401-800 ft	1.16	0.58	1.01	0.68	0.91	**1.91***	0.95	1.00
801-1200 ft	**1.75***	0.97	1.02	1.07	1.29	0.98	1.11	1.00
1201-1600 ft	1.33	0.93	0.83	0.84	0.99	1.25	0.85	1.00
1601-2000 ft	1.21	1.02	1.27	0.95	1.08	1.11	1.24	1.00
2001-2400 ft	0.93	1.02	1.30	**1.54***	1.19	0.98	1.27	1.00
2401-2800 ft	1.19	1.30	0.99	1.07	0.99	0.69	0.75	1.00
2801 ft +	0.95	**1.11***	**1.13****	**1.13****	**1.08***	**1.14****	**1.06***	1.00

Events = 1,864 (shooting n = 939; VUFA n = 925); Event pairs = 393,698
***$p < .05$; **$p \leq .01$**

In sum, there was evidence of spatial and, to a lesser extent, temporal decay in the theoretically predicted areas. All four key features of the citywide pattern were replicated here: temporal decay close by (a); immediate spatial decay in closest locations (b); longer range spatial decay (c); and targeting (d).

Two ways the results for this division contrasted with citywide results are that the Knox ratios tended to be smaller in the upper left corner of the table, and there were fewer significant ratios in the theoretically key top and left-most nine cells. Both of these may result from composition of the division, or the lower number of shooting/VUFA pairs compared to the entire city.

East Police Division (question # 1)

For the East Police Division, the division with the highest violent crime rate and lowest status score, results appear in Table 11 and pseudo *P*-values can be found in Appendix D. The Knox ratios decreased monotonically going down the first three distance intervals for the first (0 to 2 days) and third (5 to 6 days) columns. There also was a drop-off from the first time period to the second time period in each of the first two rows; ratios were lower for 3 to 4 day period as compared to the 0-2 day period for both the closest and second closest buffers. The 1 – 400 feet and 0 to 2 days cell had a statistically significant Knox ratio of 5.40. The chance of a firearm arrest immediately after a shooting and in the locations closest to it was about 440% greater than expected if there was no spatio-temporal association.

Of the four key features replicated in the Central Division from the citywide pattern, three replicated in the East Police Division: temporal decay close by (a); spatial decay in closest locations (b); and targeting (d). In the nearby and soon after cells, the only Knox ratio markedly above one, and the only one significant, is for the closest and soonest police response. Perhaps officers are so busy in this division that they do not have the resources to continue enforcement in an area after their initial response to a shooting.

Table 11: East Police Division observed over mean expected frequencies
Shooting and later VUFAs: 2004 – 2007

	Days between events							
Distance between events	0 to 2 days	3 to 4 days	5 to 6 days	7 to 8 days	9 to 10 days	11 to 12 days	13 to 14 days	15 + days
1-400 ft	**5.40****	0.86	1.68	0.78	0.77	1.36	0.73	0.99
401-800 ft	1.11	0.60	1.23	1.67	**2.18****	1.51	0.86	0.99
801-1200 ft	0.88	0.99	1.11	1.00	1.16	0.98	1.47	1.00
1201-1600 ft	1.33	1.05	**1.49***	1.41	1.11	**1.69***	1.04	0.99
1601-2000 ft	0.84	0.91	1.21	0.99	1.20	1.33	0.58	1.00
2001-2400 ft	1.09	**1.52***	0.99	1.31	0.80	1.25	1.35	1.00
2401-2800 ft	1.07	1.11	0.90	0.91	1.10	0.82	0.74	1.00
2801 ft +	1.02	1.05	1.00	0.93	**1.05***	1.05	1.04	1.00

Events = 1,995 (shooting n = 1,080; VUFA n = 915); Event pairs = 484,121
***$p < .05$; **$p \leq .01$**

Northeast Police Division (question # 1)

Table 12 (pseudo *P*-values can be found in Appendix E) shows results of a shooting and later VUFAs for the Northeast Police Division. The Northeast Police Division was characterized by the lowest rate of shooting incidents and VUFAs, as well as the lowest violent crime rate and the highest status score.

Despite these remarkable background differences between this division and the East Police Division, the Northeast Police Division results replicated the same key features of the overall city pattern as did the East Police Division: for close by locations, lower ratios in the second period following as compared to the first period following (a), a weaker immediate response two as compared to one spatial buffer away (b), and the highest Knox ratio for the most immediate and closest response (d). The 1 – 400 feet and

0 to 2 days cell had the highest Knox ratio of 6.89 of all the analyses; the number of VUFAs was almost six times greater than would be expected on the basis of a random distribution. Although the 1 – 400 feet and 3 to 4 days cell was below one, the 1 – 400 feet and 5 to 6 days (Knox ratio = 3.96) and 7 to 8 days (Knox ratio = 3.54) cells were statistically significant. Additionally there was evidence of distance decay regarding the likelihood of an arrest after a shooting. In general the Knox ratios in the 1 – 400 feet cells were greater than those in the 401 – 800 feet cells, although those in the latter were not statistically significant. In general, as in the East Police Division, monotonic declines were seen only for the first three spatial buffers in the period immediately after.

Table 12: Northeast Police Division observed over mean expected frequencies
Shooting and later VUFAs: 2004 – 2007

	Days between events							
Distance between events	0 to 2 days	3 to 4 days	5 to 6 days	7 to 8 days	9 to 10 days	11 to 12 days	13 to 14 days	15 + days
1-400 ft	**6.89****	0.88	**3.96***	**3.54***	0.88	**3.81***	0.00	0.96
401-800 ft	1.05	0.41	1.06	1.39	2.04	1.56	0.37	1.00
801-1200 ft	0.89	1.74	1.06	0.33	0.32	0.73	1.02	1.00
1201-1600 ft	0.00	0.67	1.38	0.90	0.44	1.60	1.05	1.00
1601-2000 ft	1.06	0.74	0.91	0.97	0.71	1.24	1.75	1.00
2001-2400 ft	1.11	1.64	1.24	1.68	**1.82***	0.86	1.27	0.99
2401-2800 ft	0.51	0.79	0.86	1.06	1.65	0.38	0.99	1.00
2801 ft +	0.97	0.99	1.06	1.05	1.06	1.06	1.00	1.00

Events = 964 (shooting n = 447; VUFA n = 517); Event pairs = 110,341
$*p < .05$; $**p \leq .01$

Higher than expected ratios close to the shooting location, but 5 to 12 days later suggest, perhaps, that police return to the location a few days later, making additional firearm arrests as a result of additional investigations or information.

Northwest Police Division (question # 1)

In the Northwest Police Division, a division characterized by high status, low violent crime, high counts of shootings and VUFAs but low rates relative to the other police division; there was evidence of space-time clustering and spatial and temporal decay (see Table 13 and pseudo *P*-values can be found in Appendix F). Features of the citywide pattern replicated here were spatial decay in the closest locations (b); and targeting (d). Regarding (c), as in the East and Northeast Police Divisions, a monotonically declining response with increasing distance was seen in the period immediately following the initiating event, but only for the first three buffers.

The Knox ratio found in the top left of the table, or the 1 – 400 feet and 0 to 2 days cell was 2.93 (P = 0.01), but only two other cells reached statistical significance at the .05 level, and none of these were in the three most immediately following periods and three closest distances portion of the table. Unlike the three prior divisions reviewed above, the Knox ratios in the 1 – 1200 feet and 3 to 4 days cells were all above one. Although most Knox ratios did not quite reach statistical significance, the overall patterns observed appear to conform to one of a spatial and temporal decay.

Table 13: Northwest Police Division observed over mean expected frequencies
Shooting and later VUFAs: 2004 – 2007

	Days between events							
Distance between events	0 to 2 days	3 to 4 days	5 to 6 days	7 to 8 days	9 to 10 days	11 to 12 days	13 to 14 days	15 + days
1-400 ft	**2.93****	1.57	1.14	0.81	0.86	1.71	**3.12****	0.99
401-800 ft	1.44	1.61	1.73	1.60	1.03	1.44	1.57	0.99
801-1200 ft	1.34	1.26	1.12	1.34	0.71	1.12	0.97	1.00
1201-1600 ft	1.50	0.95	1.02	0.92	0.48	1.35	1.21	1.00
1601-2000 ft	0.91	0.69	**1.44***	1.08	1.22	1.15	1.27	1.00
2001-2400 ft	1.01	1.27	0.87	0.87	0.94	0.92	0.67	1.00
2401-2800 ft	0.93	1.28	1.35	1.33	0.91	0.89	0.90	1.00
2801 ft +	0.96	1.00	1.02	1.02	0.99	1.03	0.98	1.00

Events = 2,388 (shooting n = 1,141; VUFA n = 1,247); Event pairs = 710,687
***$p < .05$; **$p \leq .01$**

Thus, as was seen citywide and in all the other divisions reviewed so far, more VUFAs occur near and soon after a shooting than would be expected if there were no space-time association.

South Police Division (question # 1)

The South Police Division ranked just below Philadelphia overall in terms of status score but had a slightly higher violent crime rate, shootings rate, and VUFA rate than Philadelphia. As was seen in the prior three divisions, temporal decay close by (a), immediate spatial decay in closest locations (b), and targeting (d), all features uncovered in the citywide pattern replicated in this division. Spatially decaying police responsiveness in the period immediately following the incident is seen only in the three closest buffers. There were numerous pseudo *P*-values less than 0.05 in the theoretically anticipated areas (see Table 14 and pseudo *P*-values can be found in Appendix G).

Beginning with the 1 – 400 feet and 0 to 2 days cell the Knox ratio was 3.82, but no other cells in the 1 – 400 feet row were statistically significant. The 401 – 800 feet and

0 to 2 days (Knox ratio = 3.59), 401 – 800 feet and 3 to 4 days cell (Knox ratio = 2.19), and 801 – 1200 feet and 3 to 4 days cells were all statistically significant at the .05 level. What seems clearer in the first two distance buffers, not seen as distinctively in other divisions or citywide, is a clear temporal gradient of declining police responsiveness up to about six days after the initiating event.

Table 14: South Police Division observed over mean expected frequencies
Shooting and later VUFAs: 2004 – 2007

	Days between events							
Distance between events	0 to 2 days	3 to 4 days	5 to 6 days	7 to 8 days	9 to 10 days	11 to 12 days	13 to 14 days	15 + days
1-400 ft	**3.82****	1.32	0.65	1.01	0.69	1.38	0.36	0.99
401-800 ft	**3.59****	**2.19***	1.42	1.10	1.15	1.20	1.40	0.99
801-1200 ft	0.57	**2.40****	1.24	0.72	1.47	1.43	1.22	1.00
1201-1600 ft	1.50	0.79	1.10	1.19	0.18	0.99	1.42	1.00
1601-2000 ft	1.10	1.17	1.39	0.47	0.94	0.93	0.94	1.00
2001-2400 ft	1.13	1.45	1.17	0.93	0.58	0.81	1.13	1.00
2401-2800 ft	1.27	1.08	1.38	1.32	0.88	0.59	1.27	1.00
2801 ft +	0.98	1.07	**1.16****	1.06	1.04	**1.14****	1.08	1.00

Events = 1,225 (shooting n = 652; VUFA n = 573); Event pairs = 172,655
$*p < .05$; $**p \leq .01$

In total, the observed patterns suggest police may be swiftly encountering and stopping suspicious people that lead to firearm arrests near the location of a shooting. These actions were spatially and temporally focused with clear temporal gradients apparent up to six days after the shooting for the two closest buffers. More broadly, efforts in this division do appear somewhat more intense and sustained than some of the other divisions; here, police efforts seemed to extend, with one exception, for about one-eighth of a mile and for at least four days.

Southwest Police Division (question # 1)

Table 15 shows the results for the Southwest Police Division, a division with the second lowest status score and generally higher violent crime, shooting, and VUFA rates relative to the other divisions (pseudo *P*-values can be found in Appendix H). Paying close attention to the nine cells in the upper most left of the Knox table, the first column displays spatial decay and the Knox ratios drop from the first column to the second column for the first three rows, demonstrating temporal decay.

More specifically, once again the largest Knox ratio was discovered in the 1 – 400 feet and 0 to 2 days cell (Knox ratio = 3.07; *P* = 0.01; feature (d), targeting). The other features of the citywide pattern, seen in the other divisions and replicated here were stronger responses in the first as compared to the second period after the initiating incident for the two closest buffers (a), and an immediate responses that was weaker one buffer away (b). As seen in the other divisions, the monotonically declining spatial gradient of immediate police response showed only for the first three buffers, out to slightly less than a fifth of a mile (1200 feet).

Table 15: Southwest Police Division observed over mean expected frequencies
Shooting and later VUFAs: 2004 – 2007

	Days between events							
Distance between events	0 to 2 days	3 to 4 days	5 to 6 days	7 to 8 days	9 to 10 days	11 to 12 days	13 to 14 days	15 + days
1-400 ft	**3.07****	1.11	1.22	1.29	1.39	1.12	0.81	0.99
401-800 ft	1.30	0.91	1.57	0.92	0.91	1.07	0.77	1.00
801-1200 ft	1.16	1.15	1.31	0.78	1.14	0.95	0.98	1.00
1201-1600 ft	1.38	1.12	1.25	1.33	0.65	1.10	0.99	1.00
1601-2000 ft	1.33	1.33	**1.45***	1.17	1.22	1.13	0.69	1.00
2001-2400 ft	1.12	0.96	1.01	1.07	0.95	1.08	1.28	1.00
2401-2800 ft	1.10	0.95	1.28	1.06	1.05	0.88	1.26	1.00
2801 ft +	0.96	**1.05****	**1.09****	1.02	**1.04***	**1.05****	**1.04***	1.00

Events = 3,075 (shooting n = 1,600; VUFA n = 1,475); Event pairs = 1,140,141
***$p < .05$; **$p \leq .01$**

Brief summary (question # 1)

To summarize, in the citywide pattern of results in the cells of most theoretical interest, capturing police responses up to 800 – 1600 feet, about the equivalent of 2 to 4 city blocks[16] away and up to a week after the initiating event, four features were identified: temporal decay close by (a); immediate spatial decay in closest locations (b); longer range spatial decay of the immediate response (c); and targeting (d). Three of these features (a, b, d) replicated in several divisions despite the varying crime levels and demographic backgrounds in different parts of the city. Feature (c) appeared only for the first three distance buffers in several divisions. The South Police Division data showed the clearest temporal gradient of police responsiveness within two blocks of the incident. Temporally declining responsiveness was seen for the two closest blocks for up to six days following the initiating incident.

[16] Since in Philadelphia, city blocks average approximately 400 feet in length, throughout the Results and Discussion section the term block refers to increments of 400 feet.

In Philadelphia overall and in the majority of police divisions, the statistically significant Knox ratios at the top left of the table are the largest, and those that follow, although not always statistically significant, correspond to a hypothesis that police likely respond to a shooting immediately and near the location to search for suspicious people, which may lead to firearm arrests. In addition to the immediate response, police may remain watchful in the days following the shooting before the number of arrests for illegally carrying a firearm subsides and/or police shift their attention to others areas and crimes.

As noted, key results from Philadelphia overall were repeatedly replicated in each police division. The slight differences found across the different police divisions align somewhat with the notion that environmental factors influence the response of police, and that the ratio of police officers to workload may differ across city regions. The partial nature of the replications also could arise from the markedly lower numbers of event pairs in many divisions, thereby constraining the expected values. Even though *all* of the divisions mirrored most features of the citywide pattern, the size of statistically significant Knox ratios in the 1 – 400 feet and 0 to 2 days cell varied, ranging from almost two and a half in the Central Police Division to almost seven in the Northeast Police Division. The background rates of firearm arrests, as shown in Table 7, vary across divisions; this probably contributed to variations in the nearest/soonest Knox ratios across divisions. Potential explanations and implications of these and other differences across divisions are described in the following chapter.

Results for question # 2

The second question sought to test whether areas experiencing one arrest for an illegally carried firearm experienced fewer shootings nearby and in the period immediately following. Event pairs consist of cases where VUFAs preceded shootings, making the VUFA the initiating event.

Philadelphia (question # 2)

Table16 shows results of the VUFA and later shooting pairs analysis across Philadelphia for the years 2004 – 2007. As with the previous question, the rows are divided into increments of 400 feet and the columns are partitioned into increments of two days. Again, values in bold with a single asterisk indicate values where the pseudo *P*-value was less than 0.05 and those with two asterisks indicate pseudo *P*-value less than or equal to 0.01, and these cells are referred to as statistically significant (pseudo *P*-values can be found in Appendix I). To reiterate, a pseudo *P*-value of less than 0.05 indicates the observed values were less than at least 95 of the values generated from the 99 permutations.

Again, it may be beneficial to first examine the general patterns regardless of statistical significance of the Knox ratios at the top left of the table. One way to help describe the patterns is by focusing on the top-most, left-most cells, and examining the line separating ratios above one from ratios below one. If, for the first three distance buffers, and the first three periods, that line can be constructed, and separates ratios into two clear sets of cells, the position of the line helps trace two competing dynamics. Because we know that shootings beget more shootings nearby and soon after (Ratcliffe & Rengert 2008), more shootings than expected may continue to occur for a time on or near the block of the original shooting.[17] But if the VUFAs create ecological deterrence, that might eventually surface on the block and be reflected in ratios significantly below one. Of course, the statistical significance of the top-most and left-most cells is of interest as well.

The Knox ratios in the top left corner of the table are greater than one but the majority of Knox ratios in this portion of the table are below one. In the first row it appears that shooting incidents continue to happen very close to the VUFA, but these incidents appear to quiet down after a few days pass. In the second row, shooting incidents were initially greater than one but appear to subside fairly quickly, after just two days. Knox ratios in the third row were all below one, as anticipated. Knox ratios below one indicate an under-representation of shootings compared to expected values.

More specifically, observed earlier-shooting-later-VUFA pairs remained greater than expected up to 800 feet in the 0 to 2 days range and up to 400 feet in the 3 to 4 days range. However, after these initial non-significant Knox ratios that were above one, the 1 – 400 feet and 5 to 6 days cell had a statistically significant Knox ratio of 0.53 indicating the chance of a shooting incident after a VUFA was about 47 percent lower than if there were no discernible pattern. Knox ratios in the 401 – 800 feet and 3 to 4 days (0.72) and 5 to 6 days (0.75) cells were also statistically significant.

The initial Knox ratios above one might suggest that police are encountering spates of shooting incidents, the near-repeat phenomenon for shootings identified by

[17] Ratcliffe and Rengert (2008) found a significant over-representation of shooting incidents within 14 days and 400 feet of previous incidents. In contrast to the Ratcliffe and Rengert (2008) study, the current research considered the temporal order of events and also used finer temporal parameters (2 days); thus, it is not clear if a near-repeat pattern would have been discovered by Ratcliffe and Rengert using smaller time intervals or if the near-repeat patterns would be much more pounced when they are closer in time to the initiating incident and wane as time passes.

Ratcliffe and Rengert (2008), and responding by making firearm arrests. Further, the initial Knox ratios above one might outline the duration and distance the flare-up of shootings encompass; therefore, in the first two days after a VUFA, and up to about two blocks away from the arrest, a modest violence flare-up continues in space and in time. Whether the violence flare-up would have been more elevated, or more prolonged, or more spatially extensive without the VUFA is not known.

The table suggests, bearing in mind the limits of the current work (see Chapter 5), that firearm arrests might play a role in driving down later shootings nearby. The depressed levels of shootings offer support for an ecological deterrence perspective.

Although many of the Knox ratios throughout the table are significant as well, because these are not clearly temporally patterned, it is unlikely these significant depressing effects across rows at one-sixth to one-third of a mile away are due to a single firearm arrest. Numerous other space/time cells in the 1601 – 2000 feet and 2001 – 2400 feet rows were statistically significant in the theoretically expected direction, meaning fewer shootings were observed after a VUFA than would be expected by chance. The significant ratios discovered almost one-half mile away, however, do not likely reflect ecological deterrence as the declines generally appear too far away from the initiating VUFA rather than soon after in the cells in the very small-scale area as theoretically anticipated.

Table 16: Philadelphia observed over mean expected frequencies
VUFA and later shootings: 2004 - 2007

	Days between events							
Distance between events	0 to 2 days	3 to 4 days	5 to 6 days	7 to 8 days	9 to 10 days	11 to 12 days	13 to 14 days	15 + days
1-400 ft	1.05	1.17	**0.53****	0.84	0.89	1.76	1.06	1.00
401-800 ft	1.22	**0.72****	**0.75***	0.79	1.18	0.80	0.97	1.00
801-1200 ft	0.77	0.95	0.90	0.85	**0.65****	0.94	0.79	1.00
1201-1600 ft	1.02	0.93	0.98	**0.87***	0.84	0.86	0.95	1.00
1601-2000 ft	**0.81***	0.95	0.99	0.84	**0.85***	0.88	**0.80***	1.00
2001-2400 ft	0.92	**0.83***	0.89	0.84	1.13	0.92	**0.85***	1.00
2401-2800 ft	0.85	0.98	**0.81***	0.89	1.02	0.99	0.92	1.00
2801 ft +	**0.95****	**0.97****	**0.94****	**0.94***	**0.97****	**0.97****	**0.93****	1.00

Events = 11,511 (VUFA n = 5,652; shooting n = 5,859); Event pairs = 17,347,253
***$p < .05$; **$p \leq .01$**

To summarize, although the observed pattern of non-significant space-time clustering is initially in the reverse direction compared to what was anticipated, it may be consistent with what is known about near-repeat patterns of shootings, and eventually there does appear to be a rather abrupt drop in shootings as theoretically predicted.

To return to the broad patterning of the Knox ratios, and focus on where they switch from above one to below one in the nine top-most, left-most cells, the following features are evident in the pattern.

(a) A line at this switch over point does separate the ratios into two homogeneous regions of cells (homogeneity).

(b) The line separating the regions forms a rising step pattern, going from left to right. The ratio drops below one immediately after the arrest at a distance of 800 – 1200 feet, drops below one at a distance of 400 – 800 feet about 3 to 4 days after the arrest, and drops below one within 400 feet of the arrest about 3 to 4 days after (rising).

(c) By 5 to 6 days after the initial arrest, the Knox ratio within a block of that arrest is *significantly* less than one (significant proximate impact).

(d) At some point, perhaps up to and including the 5 to 6 day period, in the region more than a block away at least one Knox ratio was significantly below one (significant more distant impact).

It will be interesting to see which features of the citywide pattern replicate across different police divisions. Less consistency across divisions is anticipated than was seen for data relevant to question one because here the patterning is dependent upon local residents, not one police department.

Central Police Division (question # 2)

The Central Police Division was characterized by the highest shootings rate, the highest VUFA rate, and the second highest violent crime rate of all the divisions yet a relatively average status score. Again focusing on the left and top most nine cells, one can see the observed pairs are above one for a short time and distance and quickly drop to below one as one moves from left to right and up to down (see Table 17 and pseudo *P*-values can be found in Appendix J). This pattern suggests very short-term and spatially concentrated shooting flare-ups, a swiftly diminishing intensity of shootings as one moves away from the location where the arrest was made. A firearm arrest is followed by (non-significantly) more VUFA/shooting incident pairs than would be expected based on chance spatially up to 800 feet, and temporally this pattern generally lasted for only about two days. As witnessed across Philadelphia as a whole, after the elevated levels of shootings following a VUFA for a short time period and short distance, there is again a significantly lower number of observed pairs than would be expected based on chance in the 1 – 400 feet and 5 to 6 days cell (Knox ratio = 0.21; $P < 0.05$). During this period in this location, the arrests may have resulted in ecological deterrence on the order of 79 percent. Also, the majority of other cells within a few blocks and less than one week were below one as theoretically anticipated.

Table 17: Central Police Division observed over mean expected frequencies
VUFA and later shootings: 2004 - 2007

	Days between events							
Distance between events	0 to 2 days	3 to 4 days	5 to 6 days	7 to 8 days	9 to 10 days	11 to 12 days	13 to 14 days	15 + days
1-400 ft	1.22	1.21	**0.21***	0.78	0.58	1.01	0.67	1.00
401-800 ft	1.47	0.62	0.92	0.77	0.88	0.66	0.62	1.00
801-1200 ft	0.71	0.93	0.89	0.90	**0.56***	0.55	0.92	1.00
1201-1600 ft	**0.35****	0.78	0.87	0.86	0.84	0.97	1.09	1.00
1601-2000 ft	0.86	1.09	1.11	**0.62***	**0.66***	0.66	0.77	1.00
2001-2400 ft	0.75	0.68	1.10	0.82	1.13	0.92	0.76	1.00
2401-2800 ft	0.73	0.99	**0.65***	0.76	0.84	0.78	0.86	1.00
2801 ft +	**0.91****	**0.86****	**0.88****	**0.92****	**0.91****	**0.91****	**0.93****	1.00

Events = 1,870 (VUFA n = 925; shooting n = 939); Event pairs = 475,816
$^*p < .05$; $^{**}p \leq .01$

In thinking about specific features of the citywide pattern, in the Central Police Division three features of the city–wide pattern replicated: homogeneity (a), rising (b), and a significant proximate impact (c). A significant more distant impact (d) was not seen.

In summary, in this division, soon after and near a firearm arrest, shootings remained slightly higher than expected but later diminished significantly below the expected rate within a block of the arrest. Again, the pattern might suggest that police are responding to an up-tick of shootings and making firearm arrests and the benefits of these arrests, in the form of decreased shootings are somewhat spatially and temporally lagged. Three of the four key features seen in the citywide pattern were replicated here.

East Police Division (question # 2)

Turning attention to the East Police Division, the most dangerous and poorest of the divisions, the results (see Table 18; pseudo *P*-values can be found in Appendix K) replicated one of the four features noted citywide: a significant more distant impact (d) of earlier VUFAs on later shootings was seen in two instances among the theoretically central nine top-most, left-most cells. Because the top-most, left-most cell had a Knox ratio below one, it was not possible to separate the key nine cells into two homogeneous regions. Further, although the Knox ratios within a block of the initial arrest were below one for the third and fourth periods after the arrest, these ratios were not significant.

Generally then, the East Police Division revealed a varied association between the timing and location of a VUFA followed by shootings. There does not appear to be a smooth pattern of increasing or decreasing ratios. Although only three of the cells of the nine of most theoretical interest are above one, the cells in the first two columns appeared to alternate between being above one and below one, thus not displaying a clear spatial or temporal pattern. However, observed pairs of VUFAs and shooting incidents were below one in *all* the 1 – 1200 feet and 5 to 6 days cells, suggesting that a VUFA might suppress later shooting incidents after lengthy delay.

Table 18: East Police Division observed over mean expected frequencies
VUFA and later shootings: 2004 – 2007

	Days between events							
Distance between events	0 to 2 days	3 to 4 days	5 to 6 days	7 to 8 days	9 to 10 days	11 to 12 days	13 to 14 days	15 + days
1-400 ft	0.72	1.40	0.26	0.54	1.70	1.29	2.04	1.00
401-800 ft	1.10	0.57	**0.23***	0.97	1.05	0.51	1.23	1.00
801-1200 ft	**0.59***	1.20	0.65	1.20	**0.42***	1.03	0.51	1.00
1201-1600 ft	1.35	1.27	0.84	0.79	0.62	0.76	0.73	1.00
1601-2000 ft	0.75	0.84	1.00	0.88	1.05	0.99	**0.47***	1.00
2001-2400 ft	0.75	0.96	0.99	0.82	1.00	1.49	0.89	1.00
2401-2800 ft	0.82	0.82	1.08	1.03	1.19	1.36	1.07	1.00
2801 ft +	**0.88****	1.00	0.99	**0.95***	**0.93****	0.98	**0.92****	1.00

Events = 1,995 (VUFA n = 915; shootings n = 1,080); Event pairs = 508,990
***$p < .05$; **$p \leq .01$**

Northeast Police Division (question # 2)

Next, results for the Northeast Police Division are presented in Table 19 and pseudo *P*-values can be found in Appendix L. The Northeast Police Division is characterized as being the least densely populated division, having the highest status score, and a violent crime rate less than half that of Philadelphia. The Northeast Police Division had the lowest shootings and VUFA rates and experienced the fewest number of VUFAs and shootings.

In this division, as in the East Police Division, only the significant more distant impact feature (d) of the citywide pattern replicated. About 5 to 6 days following an arrest, between one to two blocks away from the initial arrest, shootings were significantly lower.

Whereas Philadelphia and the Central Police Division experienced an initial over-representation of shootings after a VUFA, in the Northeast Police Division the vast majority of Knox ratios were below one in the first three columns and rows in the upper left of the table. There does not appear to be a clear pattern of temporal or spatial decay or an upsurge in events across space and time. Further, the vast majority of cells were not statistically significant.

Table 19: Northeast Police Division observed over mean expected frequencies
VUFA and later shootings: 2004 - 2007

	Days between events							
Distance between events	0 to 2 days	3 to 4 days	5 to 6 days	7 to 8 days	9 to 10 days	11 to 12 days	13 to 14 days	15 + days
1-400 ft	0.73	0.00	0.98	1.56	1.38	5.12	0.00	0.99
401-800 ft	0.99	0.73	**0.00***	1.08	0.67	0.67	2.04	1.00
801-1200 ft	0.54	0.80	1.09	0.84	0.80	0.91	0.77	1.00
1201-1600 ft	1.08	0.84	1.14	1.57	0.60	1.04	1.45	1.00
1601-2000 ft	0.36	1.35	1.80	1.26	**0.19***	1.71	0.80	1.00
2001-2400 ft	1.75	0.73	0.76	0.58	1.28	0.95	1.09	1.00
2401-2800 ft	0.80	1.39	1.39	0.55	0.67	1.01	0.72	1.00
2801 ft +	0.93	1.09	0.95	0.97	**0.87****	0.98	0.94	1.00

Events = 964 (VUFA n = 517; shooting n = 447); Event pairs = 121,275
$*p < .05$; $**p \leq .01$

Despite the general lack of significance, the overall lower than expected shooting ratios after a VUFA is encouraging in terms of shootings prevention and ecological deterrence. Clearly, the lack of VUFAs and shooting incidents in the Northeast Police Division might have contributed to the somewhat divergent results compared to Philadelphia overall. Comparisons between the observed and null hypotheses are difficult to make if the volume of the observed values in a cell (which the null hypothesis is based on) are very low.

Northwest Police Division (question # 2)

Table 20 shows the results for the Northwest Police Division (pseudo *P*-values can be found in Appendix M), a division that mirrored Philadelphia overall in terms of its violent crime rate but with the second highest status score.

In this division two of the four key features of the citywide pattern replicated: homogeneity (a), and rising (b). Although by 5 to 6 days following the initial arrest, the Knox ratio within a block of the initial arrest had dropped below one, it was not significantly below the expected value. Similarly, for that period and the earlier one, Knox ratios below one were seen two to three blocks away from the initial arrest, but the ratios were not significantly less than expected.

Similar to Philadelphia overall and the East Police Division, the Knox ratios are initially over one. The 1 – 400 feet and 0 to 2 days cell had a non-significant over-representation of shootings after a VUFA with a Knox ratio of 1.80. Overall, the first column and row display (respectively) a clear monotonic spatial and temporal gradient. The initial non-significant over-representation of shootings lasted up to about 800 feet and for two days. Thereafter in the nine key cells the Knox ratios dropped below one, although not enough for the departures from expected values to be significant.

Table 20: Northwest Police Division observed over mean expected frequencies VUFA and later shootings: 2004 – 2007

	Days between events							
Distance between events	0 to 2 days	3 to 4 days	5 to 6 days	7 to 8 days	9 to 10 days	11 to 12 days	13 to 14 days	15 + days
1-400 ft	1.80	1.25	0.60	0.81	**0.00***	1.80	1.30	1.00
401-800 ft	1.31	0.69	0.98	0.99	1.15	1.48	0.93	1.00
801-1200 ft	1.00	0.99	0.94	0.58	0.80	1.20	1.23	1.00
1201-1600 ft	1.43	1.04	**0.53***	0.69	1.30	0.90	1.36	1.00
1601-2000 ft	0.85	0.93	0.66	0.86	0.95	0.90	1.07	1.00
2001-2400 ft	0.88	0.89	0.86	0.72	1.34	0.67	0.67	1.00
2401-2800 ft	0.96	1.25	0.70	0.92	1.08	0.78	0.83	1.00
2801 ft +	0.97	1.00	0.99	0.97	1.02	0.97	0.99	1.00

Events = 2,388 (VUFA n = 1,247; shooting n = 1,241); Event pairs = 717,955
***$p < .05$; **$p \leq .01$**

In sum, although none of the Knox ratios in the theoretically key portion of the table are statistically significant, descriptively the pattern suggests that shooting flare-ups were temporally concentrated and geographically restricted. Also, reductions in shooting incidents materialized, perhaps due to ecological deterrence, after a couple of days and not very far from the initial event. Compared to the citywide pattern, two of the four features, homogeneity (a) and rising (d), were seen.

South Police Division (question # 2)

The South Police Division's violent crime rate was similar to that of Philadelphia overall, and had a slightly lower status score. The pattern of VUFA and later shooting pairs for the South Police Division (see Table 21) also displayed a similar non-statistically significant pattern in the nine cells for the nine most recent and closest space-times cells (pseudo *P*-values can be found in Appendix N). None of the four key features seen in the citywide pattern were exactly replicated with the results from this division but aspects of the patterns were comparable.

Focusing on the upper most left corner of the Knox table, the frequency of shootings appeared to drop off monotonically for the first follow up period up to a distance of about three blocks away. Although not statistically significant, the Knox ratios for locations from one to three blocks away from the initial arrest, for the first two periods immediately after an arrest, were below one. The clustering of values that are both close in space and time might be an indicator of ecological deterrence. Specifically why the observed patterns might be an indicator of ecological deterrence is further elaborated on in the next chapter.

Table 21: South Police Division observed over mean expected frequencies
VUFA and later shootings: 2004 – 2007

	Days between events							
Distance between events	0 to 2 days	3 to 4 days	5 to 6 days	7 to 8 days	9 to 10 days	11 to 12 days	13 to 14 days	15 + days
1-400 ft	1.00	1.46	0.72	1.13	0.43	2.21	1.82	1.00
401-800 ft	0.96	0.58	1.04	0.93	0.77	0.58	0.72	1.00
801-1200 ft	0.59	0.98	0.90	0.82	0.64	1.05	0.72	1.00
1201-1600 ft	0.96	**0.14****	1.28	0.89	0.81	0.80	0.59	1.00
1601-2000 ft	1.03	0.74	0.73	0.68	0.67	0.93	1.14	1.00
2001-2400 ft	1.08	0.86	0.65	0.77	0.97	0.71	0.78	1.00
2401-2800 ft	0.99	0.92	0.92	1.12	1.17	0.95	0.77	1.00
2801 ft +	**0.86****	0.95	**0.89****	**0.90***	1.07	**0.84****	**0.84****	1.00

Events = 1,225 (VUFA n = 573; shooting n = 652); Event pairs = 199,471
$*p < .05$; $**p \leq .01$

Southwest Police Division (question # 2)

Results from the Southwest Police Division are shown in Table 22 (pseudo *P*-values can be found in Appendix O). The Southwest Police Division's violent crime rate was near that of Philadelphia as a whole, yet relative to the other divisions it had the second lowest status score. None of the four key features seen in the citywide pattern appeared for the results of this division. The nine theoretically central cells in the table did, however, exactly mimic the pattern seen in the East Division (Table 18) in terms of the patterning of Knox ratios above and below one. Also, the general pattern, although not replicated, did to an extent follow the citywide pattern in that the three cells in the upper homogeneous region were greater than the cells in the lower region.

VUFA and later shooting pairs were slightly under-represented in the 1 – 400 feet and 0 to 2 days cell with a Knox ratio of 0.93. The adjacent space/time cells (1 – 400 feet/3 to 4 days and 400 – 800 feet/0 to 2 days), however, were slightly above one, which was consistent with many of the prior findings. Further, within about a quarter of mile and one week the Knox ratios were below one but generally not statistically significant.

The Knox ratio within a block of the initial arrest did eventually drop below one by 5 – 6 days after, but it was not significantly below the expected value.

Table 22: Southwest Police Division observed over mean expected frequencies
VUFA and later shootings: 2004 - 2007

	Days between events							
Distance between events	0 to 2 days	3 to 4 days	5 to 6 days	7 to 8 days	9 to 10 days	11 to 12 days	13 to 14 days	15 + days
1-400 ft	0.93	1.11	0.76	0.72	1.17	1.29	0.58	1.00
401-800 ft	1.18	0.90	0.78	**0.48***	1.77	0.96	0.70	1.00
801-1200 ft	0.92	0.58	0.94	0.73	0.68	1.15	0.68	1.00
1201-1600 ft	1.05	1.10	1.29	0.84	0.75	0.88	0.87	1.00
1601-2000 ft	**0.55****	0.88	0.97	0.86	1.04	0.94	0.68	1.00
2001-2400 ft	0.89	0.81	0.82	0.95	1.05	0.86	1.02	1.00
2401-2800 ft	0.76	1.00	0.73	0.82	0.87	0.95	1.09	1.00
2801 ft +	**0.92****	**0.95****	**0.93****	**0.93****	0.98	1.01	**0.90****	1.00

Events = 3,075 (VUFA n = 1,475; shooting n = 1,600); Event pairs = 1,221,078
$*p < .05$; $**p \le .01$

In this division, shooting flare-ups after a VUFA were modest, not prolonged, and spatially focused. Ratios were only modestly above one in two of the nine key cells. Police could be reacting to the location of shootings and making an arrest; ensuing shootings as part of near-repeat shooting patterns were not sizable or temporally drawn-out.

Brief summary (question # 2)

To summarize, across Philadelphia, following a VUFA, the shooting ratios generally decline, moving away in space and time for the first three rows and columns. The pattern is consistent with the idea of two competing dynamics: the waning of a near-repeat phenomenon, and reduced shootings perhaps arising from ecological deterrence. Focusing on the nine most theoretically crucial cells in the table, Philadelphia had three significant Knox ratios in the expected direction, and the Central Police Division had one significant ratio in the expected direction. In descriptive terms, four key features were identified in the citywide pattern, and three of these replicated in the Central Police Division.

CHAPTER 5:

DISCUSSION

The discussion section below reviews the major findings for the first question and then further elaborates on what the observed patterns might signify in terms of police responsiveness, as well as how and why observed patterns might slightly differ by police divisions. Attention is focused broadly on police behavior and on implications of the general patterns for theory and law enforcement. Next, results for the second question are briefly reviewed followed by a discussion of potential explanations for the observed patterns and what they might mean in terms of ecological deterrence and the location and timing of violence. The section concludes by describing the limitations and strengths of the current research and possible avenues for future research.

Results summary for question # 1

The first question explored the relationship between a shooting and subsequent police firearm arrests. Across Philadelphia in a small-scale area over a very short time period there was an over-representation of VUFAs following a shooting, approximately 260 percent times greater than would be expected under a random distribution hypothesis. Knox ratios were highest closest to and immediately following the initiating event.

Still focusing on the closest areas in the first period following the shooting, VUFAs' Knox ratios were initially above one and declined in clear monotonic pattern -- a distance decay effect -- for about one-quarter of a mile.

Temporal decay of the VUFA arrests response to a shooting was seen up to about two blocks away. When comparing the immediate response in the first two days to the later responses in the following two days, the latter ratios were lower by comparison.

Some of these Knox ratios were statistically significant at the .05 level. Analyses conducted by police division revealed similar patterns in that there was an initial and statistically significant Knox ratio at the 1 – 400 feet and 0 to 2 days cell. In Philadelphia overall, the Northwest, South, and Southwest Police Divisions the elevated Knox ratios were concentrated in the nine cells closest in space and time. In contrast to the divisions just mentioned, however, the Central and East Police Division both experienced a slight drop below one of the Knox ratios in the 3 to 4 days column before returning to above one. These Knox ratios farther away tended to be non-significant. Lastly, in the Northeast Police Division the Knox ratios in the 1 to 400 feet row were generally above one and statistically significant but also continued at that level for over one week, which was unique to this division.

Discussion for question # 1

The patterns suggest that after a shooting incident police are much more likely to make an arrest for illegal firearm carrying close by in time and space, compared to places/times with no shooting incident. What may be happening here? Except in the rare occurrence when a police officer witnesses a shooting, police dispatched to a shooting go directly to the location of the shooting. Once at the location, hypothetically in the process of searching for suspects, they increase citizen contacts; questioning, frisks and/or searches of automobiles ensue resulting in an increase in the detection and confiscation of illegal firearms and the arrest of people illegally carrying them.

In addition to responding immediately when dispatched to a shooting, the swiftness and local nature of the over-representation of illegal firearm arrests following a shooting may suggest police officers are acting on their own initiative and informally, responding to information gathered on the street and shared among officers. Police officers, in some time-permitting instances, soon return to the location of the prior shooting to conduct a follow-up investigation, and during this process they might question and search individuals, those actions lead to the detection of illegal firearms. In some cases there were elevated patterns of illegal firearms arrests across a slightly broader area after shootings, and the elevated shooting incident/VUFA pairs were significantly over-represented for an extended time period. This persistent over-representation may suggest that more formal dynamics were at work; perhaps superiors were directing officers, who complied, to concentrate arrests on people illegally carrying firearms.

The observed patterns of shooting/VUFA pairs were somewhat altered by varying the environments in which interactions between police and those who were arrested for illegally possessing a firearm took place. The stretch of time or space decay varied across districts but overall there were numerous commonalities in the patterns observed. Three out of four features in the citywide patterning of earlier shooting-later VUFA pairs appeared in all six of the police divisions: the most intense police response closest to and immediately following the incident (targeting), in the two closest buffers, stronger responses in the first two days following the incident as compared to 3 to 4 days later (temporal decay close by), and responses that were weaker one buffer away as compared to the nearest buffer, immediately following the initiating incident (immediate spatial decay in closest locations).

Although a considerable amount of research has demonstrated how police respond to crime under varying ecological conditions (Klinger, 1997; Kohfeld & Sprague, 1990; Smith, 1986), shooting incidents, no matter where they occur, it appears, are treated as priorities requiring immediate action. Therefore, it was not surprising to find the above noted commonalities in the patterning of VUFAs after a shooting.

Despite many similarities among the patterns uncovered, as mentioned above, there were some differences across divisions. For the nearest buffer, the Central and East Police Divisions both experienced initial spikes in shooting/VUFA pairs that subsided in the 3 to 4 days period but again rose above one. In that same nearest buffer, the Northeast Police Division experienced the greatest number of significantly elevated levels of shooting/VUFA pairs extending, to over one-week in the 1 – 400 feet buffer.

What might explain the slight differences in the patterns found in the East, Central, and Northeast Police Divisions compared to Philadelphia overall? The East and Central Police Divisions have the two highest violent crime rates, whereas the Northeast Police Division had the lowest violent crime rate. Although all three divisions displayed initially elevated and significant Knox ratios in the 1 – 400 feet and 0 to 2 days cell, a major difference however, was that in the East and Central Police Divisions there appeared to be an over-representation of VUFAs primarily in the 0 to 2 days column, but the over-representation did not continuously extend past the first two days after a shooting. By contrast, in the Northeast Police Division, shooting/VUFA pairs were over-represented in the 0 to 2 days column *and* this over-representation in the 1 – 400 feet row extended for over one-week.

As time passes following a shooting incident, the observed local patterning of shooting/VUFA pairs might be shaped by many features, such as available resources in police districts, general patterns of crime in an area, or work group norms. In the high crime areas police might be so busy responding to calls that after an immediate arrest they may be compelled to move on to other pressing issues. Ethnographic work in Philadelphia has documented that in high crime neighborhoods police are often overwhelmed responding to high priority calls such as an officer in need of assistance or a rape, leaving little time to engage in proactive police work or even respond to lower priority calls (Gilderman, 2006). In areas with less crime, police might have more time to search an area after a serious crime; further, they may even have time to remain in the area to continue an investigation because they are not busy responding to a series of priority calls for service.

Lastly, the Central and Southwest Police Divisions both have a number of significantly elevated Knox ratios in the furthest away buffers (2801 feet + row). It is unlikely that police would respond to a shooting by concentrating attention and making arrests approximately one half of a mile or more away from the shooting incident and at the same time ignoring the area closer to the shooting.

A closer look at the composition of the Central and Southwest Police Divisions might shed light on this unique result. There is a considerable amount of heterogeneity regarding shootings and firearm arrest levels within the Central and Southwest Police Divisions. For example, in the Central Police Division during the years 2004 to 2007 the

6th and 9th police districts, two of the four districts that make up the Central Police Division, had some of the lower shooting and VUFA frequencies relative to other districts (see Appendix A for VUFA and shooting district details). Further, these two districts were generally not plagued by crime and at the same time had a couple of the highest status scores. Conversely, during the same time period, the other two districts that comprised the Central Police Division, the 22nd and 23rd police districts, had two of the highest numbers of shootings and VUFAs as well as some of the highest violent crime rates and lowest status scores relative to the other police districts. The very high number of VUFAs and shootings in the 22nd and 23rd police districts may be unduly influencing the results in this division. A general high number of VUFAs occurring in the 22nd and 23rd police districts may be pairing with the relatively lower number of shootings occurring in the 6th and 9th police districts.

Similarly, in the Southwest Police Division, composed of four police districts, the two police districts with the greatest number of shooting incidents and VUFAs are separated in space from the two police districts with lower counts of shooting incidents and VUFAs. However, it is not clear whether these extreme differences caused the significant findings found in the last rows of Knox tables for these divisions.

Beyond examining differences across police divisions and considering the patterns observed more broadly, these results may be providing information about how police produce arrests. Various theories on police behavior outline varying conditions or circumstances that lead police to make arrests. For example, the dragnet hypothesis suggests a positive relationship between arrests for minor crimes and serious crimes. Since police more easily establish probable cause for minor crimes, police actively seek out minor crimes in the hopes of uncovering information on more serious crimes (Britt & Tittle, 1975). Although it seems plausible that as police increase citizen contacts as part of information-gathering following a shooting incident leading to the detection of more illegal firearms, a simpler alternative and equally plausible dynamic is that police are using a serious crime to uncover other minor or serious crimes. Police are less inhibited about contacting citizens since the shooting can be used to provide probable cause. The serious crime is therefore used to produce other types of arrests, VUFAs among them.

Police responding to a shooting by making firearm arrests may have benefits for a community. According to Ratcliffe and Rengert (2008), a quick response by police to a shooting can be reassuring to community members by demonstrating the police are committed to addressing serious problems. The current research, however, cannot test how these police actions resonate with community members. Also, considering that recent research in Philadelphia suggested that a shooting is often followed soon after and in close proximity by a subsequent shooting, likely due to retaliation or escalation (Ratcliffe & Rengert, 2008), an emphasis on making illegal firearm arrests after shootings may help limit retaliatory shootings. A reactive deployment of officers immediately to an area after a shooting incident may be an effective enforcement strategy used by police to minimize retaliatory shootings. An interesting avenue for future research would be examining the strength of the near-repeat shooting patterns as a function of the volume or timing of VUFAs following an initial shooting.

In sum, several theoretically predicted features emerged across Philadelphia and separately in each of the police divisions. Most importantly, police efforts were targeted and at the highest level of firearm arrests were found in the location nearest to the initiating shooting, and in the period immediately following. Further, and consistent with ethnographic work by Herbert (1997), the immediate response was spatially graded, with declining responsiveness further away. The spatial extent of this gradient varied depending on the division, but it was always seen for the first two buffers. Similarly, temporal decay of police responsiveness was always seen in the most immediate buffer comparing the 0 to 2 days vs. 3 to 4 days ratios. An elevated pattern of VUFAs occurring very close to shootings were witnessed for only a couple of days in all cases but in one instance these elevated patterns lasted for up to 10 days. Finally, the elevated initial Knox ratio that quickly drops to below expected levels in the highest crime divisions might suggest police only have time to respond to the initial shooting whereas in the lowest crime division police with greater resources and less pressing issues may be able offer a more persistent presence.

Results summary for question # 2

After briefly reviewing the findings for question two, the section below offers potential explanations regarding the observed patterns of VUFAs and shootings in relationship to ecological deterrence theory, incapacitation, and our understanding of hot spots of violence. In order to enhance our understanding of the effects of arresting people who are illegally carrying firearms as a means to reduce shootings, and more generally the degree of variation of deterrence across space and time, this study examined spatio-temporal links between a police firearm arrest and subsequent shootings nearby and soon after. Focusing on the left-most and top-most nine cells, the observed pairs displayed spatial and temporal gradations. In most cases the Knox ratios were above one for a few days and about one block but they dropped below one as one moves away in time and space. The citywide pattern clearly separated Knox ratios in these cells into two homogeneous regions. These two regions may correspond to times and locations driven largely by repeat-shooting dynamics (Ratcliffe & Rengert, 2008) in the times and places closest to the VUFA (Knox ratios above one), and to later times and/or locations further away where incapacitative or ecological deterrent dynamics may have been at play (Knox ratios below one).

Discussion for question # 2

Perhaps the most important practical implication of the current results comes from the finding that, after a temporal and spatial lag, at least one statistically significant Knox ratio below one occurred within about a week and within a couple of blocks from the initial arrest (citywide, Central, East and Northeast Police Divisions). This finding could support the idea that a firearms arrest suppressed later shootings. Theoretically, these lower than expected levels of shootings may be due to ecological deterrence and/or incapacitative effects, or other dynamics. Although the Knox ratios were initially slightly above one (top left corner of table, citywide, Central and Northwest Police Divisions), the decline in shootings after a VUFA is what would be expected with a fading of a near-repeat shooting phenomenon. Having the ratios dip *significantly* below their expected level is in line with ecological deterrence and/or incapacitative dynamics. Citywide, soon after and close to a firearms arrest, the chances of a subsequent shooting incident were about 25 to 50 percent less than expected if the events were not spatio-temporally related.

Generally, studies have not been explicit about how much time must pass before an arrest affects later criminal activity, or about the strength of those associations. This confusion was noted by Cousineau (1973), and work since then has suggested deterrent temporal lags of a day to a year, depending on the unit of analysis.

Instead of a VUFA prompting an immediate decline, which could represent either deterrent or incapacitative effects, fewer shootings appeared to show up a short time later. Specifically, the patterns suggested that significant effects of an illegal firearms arrest on later shootings, if they showed up at all, did not materialize for approximately two days.

Why the lagged or sleeper effect? Assuming deterrent effects are mechanisms leading to the decline, the delay may represent the time needed for information about police actions to reach others in nearby locations. Alternatively, if near-repeat shooting dynamics (Ratcliffe & Rengert, 2008) were operating locally in relationship to an even earlier (unmeasured here) shooting that led to the VUFA in the first place, those dynamics may have taken time to dissipate.

The temporally lagged appearance of Knox ratios nearby significantly below one might be evidence that incapacitative effects were *not* responsible for the patterns seen here. Removing a dangerous individual may reduce local tensions and shootings in a small-scale area. It is less likely, however, to be associated with a reduction in shootings over a much wider area. Incapacitative effects, given the small sized buffers used here, arguably should have produced more immediate impacts.

So significant suppression of later shootings following a VUFA appeared. But how long did they last? Although past work has demonstrated that ecological deterrence effects from police crackdown actions per se are often short lived (Ross, 1982; Sherman, 1990), there is still considerable ambiguity about the longevity of these ecological deterrence effects. Here, citywide, the observed/expected VUFA-shooting pair Knox ratios dipped significantly below one in locations one buffer away, suggesting a decline in the number of shootings, after about two days. The ratio dipped significantly below one within a block of the VUFA in the 5 to 6 day period. Thus, shootings remained under-represented for about a four day period. Non-significant Knox ratios below one in some cases extended up to ten days. About 2 to 6 days may represent the approximate time span in which shootings are most strongly suppressed following a VUFA, with the effects fading later. Whether these suppressions of later shootings arise from ecological deterrence, or other dynamics, is considered more fully below.

In addition to exploring the amount of time that must pass before an arrest affects later shootings, the current research sought to clarify the spatial patterning. Citywide, from three to six days after the VUFA, Knox ratios were significantly below one in the 401 – 800 feet buffer; from 5 to 6 days after they were significantly below one in the closest buffer. Again, assuming ecological deterrence messages leading to these under-representations in shootings, police actions suppressed shootings for a distance of about 1200 feet, or up to about three city blocks. One potential explanation of these observed patterns is that people might be initially deterred from illegally carrying and thus using a firearm in times and places near a VUFA, once there has been adequate time for them to learn about the local police activity. But, after some more time has passed, based on information from local social networks or personal experience, these same people no longer perceive an enhanced risk of apprehension and punishment. Therefore, ecological deterrence impacts wane.

Returning to the incapacitation question, could the delayed under-representation of shootings after a VUFA result from incapacitating a particularly dangerous person?

The incapacitation idea leads one to expect relatively immediate reductions in shootings, and for those reductions to be more persistent as particularly dangerous individuals have been removed from the streets, assuming the VUFA arrests lead mostly to pretrial detentions. Instead, shootings were higher relative to expected levels following a VUFA, and the Knox ratios indicating a significant under-representation of shootings were short lived. Limitations of the current research preclude a definitive answer to this question. Nevertheless, the observed patterns do not appear to point to incapacitation as the main catalyst. Instead, they seem to suggest waning near-repeat shooting dynamics coupled with some short-term ecological deterrence over a small area.

Because the lower-than-expected shootings were well patterned only in a small area, there may be theoretical implications. If one assumes ecological deterrence dynamics were operative, one might rule out deterrence via the dissemination of a threat estimate through media outlets. The information did not appear to reach a wider audience than local social networks alone would permit. Instead, the localized nature of the patterns suggest that the transmission of the threat estimate may be a result of a local social learning process, one shared through local criminal networks as argued by Stafford and Warr (1993).

Prior research has demonstrated that criminal responses to arrests may vary under different community conditions (Klinger, 1997; Kohfeld & Sprague, 1990; Smith, 1986). Focusing only on patterns of significant Knox ratios in the nine most theoretically key cells in each table suggested the observed patterns were indeed somewhat dependent on the division. That variation aside, and focusing on the patterning of ratios below one rather than significance, most divisions despite background variations in status and violent crime rates, had lower than expected VUFA/shooting pairs in the 401 – 800 feet and 3 to 4 days and 5 to 6 days cells. Also, non-significant Knox ratios in the theoretically predicted direction were also found in the 801 – 1200 feet row. In contrast to most of the other divisions, the Northeast Police Division did not experience an initial increase in the 1 – 400 feet and 0 to 2 days cell; again the lack of event pairs make comparisons difficult.

In sum, despite the initial over-representation of VUFA/shootings observed, patterns seen here still seem to support the shooting-reducing capacity of police effort in the form of a VUFA arrest. After the firearm arrest, shootings begin to calm down as shown by the temporal and spatial drop-off (the declining Knox ratios). The calming down could represent the fading of a near-repeat shooting pattern. Arguably implicit in the findings is that risk-related information about police actions is transmitted rapidly, but *not* instantaneously.

Broadly speaking, this pattern of findings highlights some of the difficulties gauging ecological deterrence; potential impacts appear to be very short-term and differentially operative at micro-spatial scales. It is unlikely that patterns suggesting deterrence impacts would have been uncovered using larger space and time lags. Even temporal increments of one-week might have conflated the initial over-representation with the subsequent significant under-representation. Likewise, even relatively small spatial units such as census block groups would have failed to differentiate these sudden changes in shooting levels. The result of sometimes-dangerous police work does appear to reduce firearm violence, just not for very long time or for very far.

Of course, the violence prevention treatment examined here is admittedly modest, i.e., just one firearm violation arrest. It would be interesting for future research to consider whether "stronger" treatments, such as pairs of VUFA arrests taking place proximate to each other in space and time, might reduce subsequent firearm violence for longer periods, or for greater distances.

Turning attention to the non-significant over-representation of shootings primarily in the 1 – 400 feet/0 to 2 days, 1 – 400 feet/3 to 4 days, and 401 – 800 feet/0 to 2 days cells, these patterns might suggest police are responding and making firearm arrests in areas experiencing a high number of shootings in space and time.

When police officers learn of violence they react and the result may be a firearm arrest. Assuming police are reacting to specific areas characterized by a temporary flare-up of shootings, as would be expected given previous findings about near-repeat patterns of shootings in Philadelphia (Ratcliffe & Rengert, 2008), and making a firearm arrest, it may be expected that high levels of violence are occurring near and soon after a VUFA. Hence, it may be helpful to focus on the events leading up to the VUFA and later shootings. In short, future work might profitably consider extending the sequence considered here to earlier points in time and space. How do localized violence flare-ups, perhaps generated by near-repeat shooting dynamics, link to later VUFAs, and how do the latter then dampen the flare-up or near-repeat dynamics?

Stated differently, it might be that the police have targeted the right address because, as these data show, that is where later violence was highest, with later violence dropping off spatially from there. Therefore, if police officers are reacting to violence and making firearm arrests in the temporal/spatial center of a flare-up, one would expect a slightly high level of shootings there. The level of violence then quickly fades or wanes with increased distance and time from the VUFA. Consequently, VUFA/shooting patterns might represent a temporary or unstable space-time cluster of violence to which police are responding. What is not known is whether the center of that flare-up would have been more intense (home to even more shootings), or as intense but for a longer time, or over as spatially extensive an area had the police not stepped in. It is not clear at this time, whether these violence flare-ups are subsumed by the near-repeat shooting dynamics identified earlier by Ratcliffe and Rengert (2008), or something somewhat different.

More broadly, the admittedly modest over-representation of earlier VUFA/later shootings in the soonest following/closest by cells might inform our understanding of violence space and time patterning. Although there is no standardized definition of a hot spot (Eck, 2005; Taylor, 2010), some have argued that hot spots imply temporal stability for a year or two (Mastrofski, Weisburd, & Braga, 2010; Sherman, 1995). For example, Sherman (1995) has defined hot spots as "small places in which the occurrence of crime is so frequent that it is highly predictable, at least over a one year period" (36).[18] Mastrofski, Weisburd, and Braga, (2010) also have argued that hot spots do not necessarily flare-up and disappear; they noted that hot spots are stable "over long time periods" (255).

In contrast to these ideas, Townsley, Homel, and Chaseling (2000) found that burglary "hotspots" may *or may not* prove stable over time. The patterning seen here argues for instability. That is, despite an assumption that hot spots are often "chronic"

---

[18] Sherman (1995) was outlining crime in general and mentioned that hot spots rarely have shootings.

(Sherman, 1995: 47), a slight over-representations in shootings gives way quickly to significant under-representations of shootings. If the VUFAs are taking place in hot spots, these hot spots might have greater temporal dynamism than previously believed.

Alternatively, it may be that hot spots are an artifact of agglomerating numerous near-repeat dynamics. The near-repeat dynamics are spatially and temporally delimited, but when analyzed at larger spatial or temporal scales appear more stable, thus producing the well-known hot spot. Whether these near-repeat shooting flare-ups in space and time are distinct from hot spots, and if so how, is not known at this time.

The relationship between question # 1 and # 2 results

So far the results answering the two different questions addressed here have been considered in isolation. At a very general level, however, it is useful to contrast these two patterns of results.

If the focus is on which descriptive features of the citywide pattern replicated across the different divisions, the features of earlier shootings/later VUFAs proved generally more consistent than the features of the earlier VUFAs/later shootings. This may be because the spatio-temporal patterning of earlier shootings/later VUFAs were driven primarily by the policies, procedures, and trained personnel affiliated with just one agency. By contrast, the patterning of earlier VUFAs/later shootings were dependent upon behavioral, ecological, and communication dynamics of potential shooters from all across the city. Considered in this light, it is less surprising that descriptive features of the citywide pattern for question number two were less consistently replicated across divisions.

Limitations and strengths

The present study sought to extend our knowledge about police responsiveness to crime and police ecological deterrence by better capturing close associations in space in time between shootings and VUFAs. The results, however, must be considered in light of important study limitations.

First, given the method used here, a modified version of the Knox approach, it would be improper to conclude that the results demonstrate a direct causal link. The modified version of the Knox approach uncovers spatio-temporal patterning and determines when these patterns are significantly different from what would be expected if the events were completely independent. There is an endogeneity problem, that is, the potential for omitted and therefore unmeasured variables (Dietz, 2002; Duncan, Magnuson, & Ludwig, 2004). There is a temporal ordering to the investigation of each question: earlier shootings are linked to later police firearm arrests, or earlier police firearm arrests are linked to later shootings. But despite this temporal ordering, there could be sources of temporal, spatial, or spatio-temporal spuriousness that are not taken into account.

Stated differently, other co-varying dynamics not captured here might be driving the connections seen. It was not possible to distinguish whether the police, other criminal justice organizations, and non-criminal justice agencies conducted operational strategies or programming that might have influenced crime and the manner in which police conducted themselves over the four-year period. For example, beginning in September 2004 the Philadelphia Police Department launched the Priority Corner Program in an attempt to limit open-air drug dealing and the associated violence. As part of the

Program, street corners identified with a history of violence received an increased uniformed police presence and intensified patrols (Ratcliffe & Rengert, 2008). This geographically localized program might have influenced the perceived risks of apprehension and the likelihood and manner of police response to violence.

More broadly, processes at higher levels of spatial or temporal aggregation may be linked to shootings and police responsiveness and play out over time and space (Ratcliffe & Rengert, 2008) in spatially or temporally covarying ways. For example, economic growth (Becker, 1968), changing demographics (Blumstein, 2006), concentrated disadvantage (MacDonald & Gover, 2005) and expanding drug markets (Levitt, 2004) are just a few common explanations for changes in crime and shootings. Clearly, these factors can have impacts independent of police efforts to detect and remove firearms.

On the other hand, some of these broader exogenous factors may not be relevant here. These factors are often operationalized at too macro a level to synch up with the short term changes in nearby locations considered here. Another important avenue for future research is the development of a more comprehensive micro-ecological theory about variations in shootings (Cork, 1999).

Second, the current research was not able to make distinctions among various circumstances surrounding VUFAs and shootings. For example, an illegal firearms arrest made at a time and place that is highly visible and thus witnessed by others might convey a greater deterrence message than a firearms arrest that occurs in a household. Likewise, the number of police officers and the vigor they use would likely vary depending on the type of call. For instance, it is reasonable to expect a greater number of officers will respond after a call goes out that a police officer was shot and the suspect is still at-large than would respond to a report of a shooting related to a domestic dispute.

Third, the observed patterns are based on incident pairs with single initiating events. The underlying assumption is that a single shooting can drive up later VUFAs, or that a single VUFA can drive down later shootings.

An alternate assumption is that there is more than one initiating event for one or both of these dynamics. Police responsiveness might have tied more clearly to earlier shootings if there was an accumulation of shootings. Likewise, if multiple VUFAs occurred in close proximity in space and time, impacts on subsequent shooting suggestive of ecological deterrence might have emerged more strongly. We also don't know what other types of arrests were happening in the same period and nearby. Criminals do not distinguish among the specific types of arrests (Cornish & Clarke, 1987). An ideal approach would be to create polygons around multiple VUFAs (and potentially other arrests) occurring close to each other in space and time, and to analyze each polygon. The currently modified program, however, does not have that capability. Examining impacts of initiating events for both question number one and number two may be a valuable avenue for future research.

One final limitation emerges from the current analytic procedure used. Given the newness of this technique, it is not certain whether Monte Carlo procedures for generating expected distributions are likely to generate an inflated experiment-wise alpha rate across an entire set of cells. In order to counter-balance this potential concern, attention was focused just on the nine cells in the three buffers and distances soonest after and closest to an initiating event, which also were the most theoretically relevant given earlier work; significance ratios which were not well patterned were not emphasized; and considerable attention was devoted to the patterning of the ratios within these nine cells, following Maltz's (1994) advice.

Perhaps partially mitigating these limitations is the current work's focus on micro-level spatio-temporal patterning. Arguably the close temporal and spatial proximities of the shootings and VUFAs highlighted here – up to six days apart, and up to three blocks apart – strengthen the likelihood that the two event types are meaningfully rather than spuriously related. This idea illustrates the first law of geography, "everything is related to everything else, but near things are more related than distant things" (Tobler, 1970: 236). An additional strength is that the current work, in contrast to prior research using the Knox approach, takes into account the sequence of events. By doing so it narrows the range of relevant plausible causes. The importance of separating out the dynamics linking these two event types based on which came first is underscored by the clearly differentiated patterns of results for the two different event sequences.

Future research

Future research avenues already have been suggested. This section highlights some avenues that may be of considerable theoretical or practical relevance.

In relation specifically to the first question, future research should explore whether other types of illegal behavior detected by police, beyond arrests for illegal firearm carrying, also increase after a shooting. Although after a shooting the theories noted here suggest police may specifically focus on detecting and confiscating illegally carried firearms, they also may increase contact with citizens and uncover other types of crimes. Police may feel less constrained to approach and stop individuals because a shooting may provide a perception of probable cause. Therefore, arrests for other crimes or conditions such as illegal drug possession or outstanding warrants also may increase. In short, a broader crackdown rather than a targeted hunt for weapons may ensue. The spatio-temporal pattern uncovered in the current research may be replicated or modified by future research considering other types of arrests, thereby furthering our understanding of situations that lead to arrests.

Turning attention to the second question, future work gauging the effectiveness of arresting those illegally carrying firearms as a way to reduce later shootings may benefit from detailed characteristics of those who are arrested. A primary concern is: To what extent do those who illegally carry firearms carry these weapons with criminal intentions or criminal consequences?

Aspects of firearm control policies assume that certain people, e.g. felons or the mentally ill, pose an unacceptably high risk because they are extremely likely to misuse firearms. Laws therefore forbid members of these groups to own firearms (Jacobs & Potter, 1995). Gleck and Gertz (1998), however, estimated that 80 to 90 percent of people who report carrying a firearm in public do so illegally, but only a very small portion of these unlawful firearm carriers do so with the intent to commit a crime beyond the violation of illegally carrying the firearm. Kleck claimed “most carrying is done for non-criminal purposes of self-defense, by people who neither intend to commit a crime nor end up doing so” (1997: 192). Further, survey results of a sample of men in prison with felony convictions conducted by Wright and Rossi (1994), reinforced this notion when they found respondents indicated that firearms were rarely acquired for use in crime and most carried firearms when traveling to an unfamiliar area as a means of self-protection.

Even though Wright and Rossi (1994) indicated that self-protection was the most common motivation for illegally carrying a firearm among those interviewed, clearly this would not preclude respondents from using their firearms criminally. In fact, given the lifestyles (e.g. drug dealing/sales) of some of the inmates, firearms carried for self-protection in some cases are associated with criminal activities and might be spontaneously used in certain situations (Wright & Rossi, 1994). If police identify and arrest those who illegally carry firearms for otherwise non-criminal purposes, firearm crimes may not decline much (Kleck & Gertz, 1998).

Arresting a person who is illegally carrying a firearm but who is at a low risk for violence might have less effect on total violence, as he or she is not an immediate threat to commit violence. Arresting those at high risk for violence might result in incapacitating a larger number of particularly dangerous individuals, thus generating greater firearm violence reductions (McGarrell et al., 2001). No data, however, have been presented in the police firearm crackdown literature on characteristics of those who were arrested. Likewise, the current research was unable to gauge whether those arrested for illegally carrying firearms were what Wright and Rossi (1986) termed “handgun predators” or simply people carrying for self-protection. An enormous amount of illegal firearm carrying is motivated by self-protection and it is not clear if removing firearms from these individuals significantly reduces shootings (Kleck, 1997). The problem is that the construct validity of using illegal firearm carrying as an indicator for later criminal shooting is completely unknown at this point. Given the policy emphases placed on arrests for illegal firearm carrying, these connections need clarification.

Who is arrested not only relates to incapacitation but also may have implications for deterrence theory. Even a simple rendering of deterrence theory specifies that people must perceive sanctions, process information on these sanctions, and weigh various aspects of the penalties associated with the sanctions (Blumstein, Cohen, & Nagin, 1978). Arresting individuals who intend to commit a crime with their firearms, or those involved in criminal activity not only halts an immediate threat, but generates news that might travel through criminal networks, thus deterring others (Stafford & Warr, 1993). Alternatively, arresting a person who is illegally carrying a firearm but who is at a low risk for violence might have less effect on total violence, as he or she was not an immediate threat to commit violence, and others criminally inclined are less likely to be aware of the arrest. Whether the arrest resonates with others who have a tendency for violence may depend on the local crime networks to which the arrestee was connected. In sum, future research should attempt to determine whether who is arrested for illegally carrying firearms moderates levels of later firearm violence.

The currently methodology could be used to help unpack which aspects (if any) of broader large scale, multi-agency collaborations such as Project Exile, Ceasefire, and Project Safe Neighborhoods aid reducing firearm violence (for a brief description of these interventions see McGarrell, Corsaro, Hipple, & Bynum, 2010). These interventions involve deterrence-based models that in part rely on increased arrests in relatively geographically limited locations. Examining specifically if arrests for illegal firearm possession reduce later shooting incidents might help aid in identifying the component of these broader interventions that were most associated with firearm violence.

Conclusion

In sum, results demonstrated close associations in space and time between firearm arrests and shootings; more importantly, the spatio-temporal nature of the association depended on which was the initiating event. There was strong support for the idea that police respond swiftly and precisely to criminal behavior, and in ways that were relatively uniform across different parts of the city. The idea that criminals respond to police behavior also received support, although this association, while significant, was not as straightforward.

Police appear to respond swiftly to a shooting by making firearm arrests near the location of the shooting. In addition to this swift response, in some cases it appears police remained watchful in the days following the shooting, arresting additional people caught illegally carrying firearms. The likelihood of a firearm arrest declined markedly as one moved away spatially and temporally from the immediate period closest to the shooting.

When police do respond, a violence prevention benefit does appear after a lag. A single firearm arrest did eventually, after a couple of days, result in fewer shootings, with the benefit eventually almost a week later appearing in the location nearest to the shooting. Shootings remained (non-significantly) higher than expected immediately after a shooting, in support of previously documented near-repeat shooting patterns in Philadelphia, but following a step-like pattern, and in line with an ecological deterrence model, dropped to significantly lower than expected levels.

The observed patterns may have implications for theory and practice. The spatio-temporal patterns observed highlight the very geographically and spatially concentrated nature of police and offender interactions. Elevated levels of shootings and police arrests for illegal possession of a firearm were discovered within very close proximity of each other, generally not beyond one-quarter of a mile or one week. Therefore, future research on police arrests for illegal possession of firearms and shootings would benefit from using finer-grained spatial and temporal units. Data analyzed across entire cities, police districts, patrol beats, census tracts and yearly, quarterly, or monthly intervals likely conflate localized impacts, and thus obscure basic features of associations between police arrests for illegal possession of a firearm and shootings.

The observed patterns have additional practical implications. Results document that police respond swiftly and concisely to shootings. Although it is not clear how patrol officers used their discretionary time, police officers do not appear to be indiscriminately making arrests but instead monitoring violence and responding accordingly. Further, it appears firearm arrests may temporarily suppress shootings.

REFERENCES

Altbeker, A. (2005). *The dirty work of democracy*. Johannesburg, South Africa: Jonathan Ball Publishers.

Becker, G. (1968). Crime and punishment: An economic approach. *Journal of Political Economy*, 76(2), 169-217.

Berk, R., & MacDonald, J. (2009). The dynamics of crime regimes. *Criminology*, 47(3), 971-1008.

Besag, J., & Diggle, P. J. (1977). Simple Monte Carlo tests for spatial patterns. *Applied Statistics*, 26, 327-333.

Blumstein, A. (1995). Violence by young people: Why the deadly nexus? *National Institute of Justice Journal*, 1-9.

Blumstein, A. (2006). The crime drop in America: An exploration of some recent crime trends. *Journal of Scandinavian Studies in Criminology and Crime Prevention*, 7, 17-35.

Blumstein, A., Cohen, J., & Nagin, D. (1978). Deterrence and incapacitation: Estimating the effect of criminal sanctions on crime rates. Washington, DC: National Academy of Sciences Press.

Blumstein, A., & Cork, D. (1996). Linking gun availability to youth gun violence. *Law and Contemporary Problems*, 59(1), 5-24.

Bottoms, A., & Costello, A. (2008). Crime prevention and the understanding of repeat victimization: A longitudinal study. In P. Knepper, J. Doak & J. Shapland (Eds.), *Urban crime prevention, surveillance, and restorative justice: Effects of social technologies*. Boca Raton, FL: CRC Press Taylor & Francis Group.

Bowers, K. J., & Johnson, S. D. (2004). Who commits near repeats? A test of the boost explanation. *Western Criminology Review*, 5(3), 12-24.

Boyum, D., & Kleiman, M. A. R. (1995). Alcohol & other drugs. In J. Q. Wilson & J. Petersilia (Eds.), *Crime*. San Francisco, CA: Institute for Contemporary Studies Press.

Britt, D. W., & Tittle, C. R. (1975). Crime rates and police behavior: A test of two hypotheses. *Social Forces*, 54(2), 441-451.

Bursik, R. J. Jr., Grasmick, H. G., & Chamlin, M. B. (1990). The effects of longitudinal arrest patterns on the development of robbery trends at the neighborhood level. *Criminology*, 28(3), 431-450.

Chainey, S., & Ratcliffe, J. (2005). *GIS and crime mapping*. London: John Wiley and Sons.

Chamlin, M. B., Grasmick, H. G., Bursik, R. J. Jr., & Cochran, J. K. (1992). Time aggregation and time lag in macro-level deterrence research. *Criminology,* 30(3), 377-395.

Clarke, R.V., & Weisburd, D. (1994). Diffusion of crime control benefits: Observations on the reverse of displacement. In R.V. Clarke (Ed.), *Crime prevention studies* (Vol. 2, pp.165-184). Monsey, NY: Criminal Justice Press.

Cohen, J., & Ludwig, J. (2003). Policing crime guns. In J. Ludwig & P. J. Cook (Eds.), *Evaluating gun policy*, (217-250). Washington, DC: Brookings Institution Press.

Cohen, J., Gorr, W., & Singh, P. (2003). Estimates intervention effects in varying risk settings: Do police raids reduce illegal drug at nuisance bars? *Criminology*, 41(2), 257-292.

Cook, P. (1979). *A unified treatment of deterrence, incapacitation, and rehabilitation: A simulation study*. Durham, NC: Duke University.

Cork, D. (1999). Examining space-time interaction in city-level homicide data: Crack markets and the diffusion of guns among youth. *Journal of Quantitative Criminology*, 15(4), 379-406.

Cornish, D. B., & Clarke, R. V. (1987). Understanding crime displacement: An application of rational choice theory. *Criminology*, 25(4), 933-947.

Cousineau, D. F. (1973). A critique of the ecological approach to the study of deterrence. *Social Science Quarterly*, 54(1), 152-158.

Cusson, M. (1993). Situational deterrence: Fear during the criminal event. In R.V. Clarke (Ed.), *Crime Prevention Studies* (Vol. 1, pp. 55-68). Monsey, NY: Criminal Justice Press.

D'Alessio, S. J., & Stolzenberg, L. (1998). Crime, arrests, and pretrial jail incarceration: An examination of the deterrence thesis. *Criminology,* 36(4), 735-762.

Decker, S. H., & Kohfeld, C. W. (1985). Crimes, crime rates, arrests, and arrest ratios: Implications for deterrence theory. *Criminology*, 23(3), 437-450.

Dietz, R. D. (2002). The estimation of neighborhood effects in the social sciences: An interdisciplinary approach. *Social Science Research,* 31, 539-575.

Dubner, S. J. (2008, August 22). What's Your Best Idea to Cut Gun Deaths? A Freakonomics Quorum. *The New York Times*. Retrieved August 28, 2008, from http://freakonomics. blogs.nytimes.com /2008/08/22/whats-your-best-idea-to-cut-gun-deaths-a-freakonomics quorum/?scp=3&sq=Dubner%20Ludwig %20guns&st=cse no.

Duncan, G. J., Magnuson, K. A., & Ludwig, J. (2004). The endogeneity problem in developmental studies. *Research in Human Development*, 1(1 & 2), 59-80.

Eck, J. E. (1993). The threat of crime displacement. *Criminal Justice Abstracts*, 24, 527-546.

Eck, J. E. (2005). Crime hot spots: What they are, why we have them, and how to map them. In J. E. Eck, S. Chainy, J. G. Cameron, M. Leiter, & R. E. Wilson (Eds.), *Mapping crime: Understanding hot spots.* NIJ special report, Washington DC: National Institute of Justice.

Fagan, J., & Davies, G. (2000). Street stops and broken windows: Terry, race, and disorder in NYC. *Fordham Urban Law Journal*, 28, 457-504.

Famega, C. N., Frank, J., & Mazerolle, L. (2005). Managing police patrol time: The role of supervisor directives. *Justice Quarterly*, 22(4), 540-559.

Farrell, G. (1995). Predicting and preventing repeat victimization. In M. Tonry & D. P. Farrington (Eds.), *Building a safer society: Crime and justice* (Vol. 19). Chicago, IL: University of Chicago Press.

Fyfe, J. J. (2004). Stops, frisks, searches, and the Constitution. *Criminology & Public Policy*, 3(3), 379-396.

Gilderman, G. (2006, November). The dead of the night. *Philadelphia Magazine*. Retrieved December 16, 2009, from http://www.phillymag.com/articles/the_dead_of_night/.

Greenberg, D. F., & Kessler, R. C. (1982). The effect of arrest on crime: A multivariate panel analysis. *Social Forces*, 60, 771-790.

Greenberg, D. F., Kessler, R. C., & Logan, C. H. (1979). A panel model of crime rates and arrest rates. *American Sociological Review*, 44(5), 843-850.

Greenberg, D. F., Kessler, R. C., & Logan, C. H. (1981). Aggregation bias in deterrence research: An empirical analysis. *Journal of Research in Crime and Delinquency*, 18, 128-137.

Greene, J. R., Piquero, A. R., Hickman, M. J., & Lawton, B. A. (2004). *Police integrity and accountability in Philadelphia: Predicting and assessing police misconduct*. Washington, DC: National Institute of Justice/NCJRS.

Hannan, M. T. (1971). Problems of aggregation. In H. M. Blalock (Ed.), *Causal models in the social sciences* (pp. 473-508). Chicago, IL: Aldine.

Herbert, S. (1997). *Policing space: Territoriality of the Los Angeles Police Department*. Minneapolis, MN: University of Minnesota Press.

Jacob, H., & Rich, J. R. (1980). The effects of the police on crime: A second look. *Law & Society Review*, 15(1), 109-122.

Jacobs, J. B., & Potter, K. A. (1995). Keeping guns out of the "wrong" hands: The Brady Law and the limits of regulation. *Journal of Criminal Law & Criminology, 86*, 93-120.

Johnson, S. D., & Bowers, K. J. (2004a). The burglary as clue to the future: The beginnings of prospective hot-spotting. *European Journal of Criminology*, 1(2), 237-255.

Johnson, S. D., & Bowers, K. J. (2004b). The stability of space-time clusters of burglary. *British Journal of Criminology*, 44, 55-65.

Johnson, S. D., Summers, L., & Pease, K. (2009). Offender as forager? A direct test of the boost account of victimization. *Journal of Quantitative Criminology*, 25(2), 181-200.

Jones, B. J., & Jones, D. R. (2000). The contagious nature of antisocial behavior. *Criminology*, 38(1), 25-46.

Kane, R. J. (2006). On the limits of social control: Structural deterrence and the policing of "suppressible" crimes. *Justice Quarterly,* 23(2), 186-213.

Kleck, G. (1991). *Point blank: Guns and violence in America*. New York: Aldine de Gruyter.

Kleck, G. (1997). *Targeting guns: Firearm and their controls*. New York: Aldine de Gruyter.

Kleck, G. (2004). Measures of gun ownership levels from macro-level crime and violence research. *Journal of Research in Crime and Delinquency*, 41(1), 3-36.

Kleck, G., & Gertz, M. (1998). Carrying guns for protection: Results from the national self-defense survey. *Journal of Research in Crime and Delinquency,* 35(2), 193-224.

Klinger, D. A. (1997). Negotiating order in patrol work: An ecological theory of police response to deviance. *Criminology*, 35(2), 277-306.

Knox, G. (1964). Epidemiology of childhood leukemia in Northumberland and Durham. *British Journal of Preventive Medicine*, 18, 17-24.

Kohfeld, C. W. (1983). Rational cops, rational robbers, and information. *Journal of Criminal Justice*, 11, 459-466.

Kohfeld, C. W., & Sprague, J. (1990). Demography, police behavior, and deterrence. *Criminology*, 28(1), 111-136.

Koper, C. S, & Mayo-Wilson, E. (2006). Police crackdowns on illegal gun carrying: A systematic review of their impact on gun crime. *Journal of Experimental Criminology*, 2, 227-261.

Kurtz, E., Malvestuto, R., Snyder, F., Reynolds, K., McHale, J., & Johnson, F. (2007). Philadelphia's Gun Court: Process and Outcome Evaluation Executive Summary. Retrieved July 30, 2007, from http://fjd.phila.gov/pdf/criminal-reports/Gun-Court-Evaluation-report-executive-summary.pdf.

Lawton, B. A., Taylor, R. B., & Luongo, A. J. (2005). Police officers on drug corners in Philadelphia, drug crime, and violent crime: Intended, diffusion, and displacement impacts. *Justice Quarterly*, 22(4), 427-451.

Levitt, S. D. (2004). Understanding why crime fell in the 1990s: Four factors that explain the decline and six that do not. *Journal of Economic Perspectives*, 18(1), 163-190.

Liska, A. E. (1990). The significance of aggregate dependent variables and contextual independent variables for linking macro and micro theories. *Social Psychology Quarterly*, *53*(4), 292-301.

Loftin, C. (1986). Assaultive violence as a contagious social process. *Bulletin of the New York Academy of Medicine*, 62(5), 550-555.

Long, S. B. (1979). The continuing debate over the use of ratio variables: Facts and fiction. In K. F. Schuessler (Ed.), *Sociology methodology*. San Francisco, CA: Jossey-Bass.

MacDonald, J. M., & Gover, A. R. (2005). Concentrated disadvantage and youth-on-youth homicide: Assessing the structural covariates over time. *Homicide Studies*, 9(1), 30-54.

Maltz, M. D. (1994). Deviating from the mean: The declining significance of significance. *Journal of Research in Crime and Delinquency*, 31(4), 434-463.

Mastrofski, S. D., Weisburd, D., & Braga, A. A. (2010). Rethinking policing: The police implications of hot spots of crime. In N. A. Frost, J. D. Freilich, & T. R. Clear (Eds.), *Contemporary issues in criminal justice policy* (pp. 251 – 264). Belmont, CA, Wadsworth.

Maykuth, A. (2007, June 05). Philadelphia leads big cities in murder rate. *Philadelphia Inquirer*. Retrieved November 15, 2008, from http://www.philly.com /philly/news/20070605_Phila__leads_big_cities_in_murder_ rate.html.

McArdle, A., & Erzin, T. (Eds.). (2001). *Zero tolerance: Quality of life and the new police brutality in New York City*. New York: New York University Press.

McGarrell, E. F., Chermak, S., Weiss, A., & Wilson, J. (2001). Reducing firearms violence through directed police patrol. *Criminology & Public Policy*, 1(1), 119-148.

McGarrell, E. F., Corsaro, N., Hipple, N. K., & Bynum, T. S. (2010). Project Safe Neighborhoods and violent crime trends in US cities: Assessing violent crime impact. *Journal of Quantitative Criminology*, 26, 165-190.

Messick, S. (1995). Validity of psychological assessment: Validation of inferences from persons’ responses and performances as scientific inquiry into score meaning. *American Psychologist*, 50(9), 741-749.

Moore, H. (1980). The police and weapons offenses. *The Annals of the American Academy of Political and Social Sciences*, 452, 22–32.

Moore, M. T. (2005, April 12). Murders on rise in Philadelphia. *USA TODAY* Retrieved from http://www.usatoday.com/news/nation/2005-12-04-murders-philadelphia_x.htm.

Moss-Coane, M. (Producer). (2006, December 14). *Whither stop-and-frisk* [audio podcast]. Retrieved from http://www.whyy.org/podcast/121406_100630.mp3.

Moss-Coane, M. (Producer). (2008, January 31). *Rudovsky responds to Ramsey plan* [audio podcast] http://www. audio/20080131_rudovsky_responds_to_ramsey _plan.mp3.

Nagin, D. (1978). General deterrence: A review of the empirical evidence. In A. Blumstein, J. Cohen & D. Nagin (Eds.), *Deterrence and incapacitation: Estimating the effects of criminal sanctions on rates* (pp. 110-174). Washington, DC: National Academy of Sciences.

Nagin, D. (1998). Criminal deterrence research at the outset of the twenty-first century. *Crime and Justice,* 23, 1-42.

Nagin, D. S., & Paternoster, R. (1991). The preventive effects of the perceived risk of arrest - testing an expanded conception of deterrence. *Criminology,* 29(4), 561-587.

Openshaw, S. (1984). The modifiable areal unit problem. *Concepts and Techniques in Modern Geography*, 38, 41.

Openshaw, S., & Taylor, P. (1979). A Million or so correlation coefficients. In N. Wrigley (Ed.), *Statistical methods in the spatial sciences* (pp. 127-144). London: Pion.

Ousey, G. C., & Lee, M. R. (2002). Examining the conditional nature of the illicit drug market-homicide relationship: A partial test of the contingent causation. *Criminology*, 40, 73-102.

Painter, K., & Farrington, D. P. (1999). Improved street lighting: Crime reducing effects and cost-benefit analyses. *Security Journal*, 12, 17–32.

Parker, J., & Grasmick, H. (1979). Linking actual and perceived certainty of punishment. *Criminology*, 17, 366-379.

Parks, R. B., Mastrofski, S. D., Delong, D., & Gray, M. K. (1999). How officers spend their time with the community. *Justice Quarterly*, 16(3), 483-518.

Pennsylvania Uniform Firearms Act. 18 Pa.C.S. § 6101. (1995). Retrieved February 25, 2010, from Pennsylvania crime code offenses http://www.pacode.com/secure/ data /204/chapter303/s303.15.html.

Pennsylvania State Police. (2010). Pennsylvania Uniform Reporting System. Retrieved February 1, 2010, from http://ucr.psp.state.pa.us/UCR/Reporting/Annual/ AnnualSumArrestUI.asp.

Philadelphia Police Department. (2007). Philadelphia Police Department: Patrol District Crime Statistics – 2006. Retrieved July 22, 2008, from http://www.ppdonline.org/ hq_ statdist_06.php.

Philadelphia Police Department. (2008). Philadelphia Police Department: Police 9-1-1 System. Retrieved July 31, 2008, from http://www.ppdonline.org/ ops_tech_911.php.

Polvi, N., Looman, T., Humphries, C., & Pease, K. (1990). Repeat break and enter victimization: Time course and crime prevention opportunity. *Journal of Police Science and Administration*, 17(1), 8-11.

Ratcliffe, J. H. (2004). Geocoding crime and a first estimate of a minimum acceptable hit rate. *International Journal of Geographic Information Science*, 18(1), 61-72.

Ratcliffe, J. H., & Makkai, T. (2004). Diffusion of benefits: Evaluating a policing operation. *Trends and Issues in Crime and Criminal Justice*, 278, 1-6.

Ratcliffe, J. H., & McCullagh, M. J. (1999). Hotbeds of crime and the search for spatial accuracy. *Journal of Geographic Systems*, 1, 385-398.

Ratcliffe, J. H., & Rengert, G. F. (2008). Near-repeat patterns in Philadelphia shootings. *Security Journal*, 21, 58-76.

Rengert, G. F., & Lockwood, B. (2008). Geographical units of analysis and the analysis of crime. In D. Weisburd, W. Bernasco & G. J. N. Bruinsma (Eds.), *Putting crime in its place: Units of analysis in geographic criminology* (pp. 109-122). New York: Springer.

Rengert, G. F., Piquero, A. R., & Jones, P. R. (1999). Distance decay reexamined. *Criminology*, 37(2), 427-446.

Robinson, W. S. (1950). Ecological correlations and the behavior of individuals. *American Sociological Review*, 15, 351-357.

Ross, L. H. (1982). *Deterring the drunk driver: Legal policy and social control*. Lexington, MA: DC Health and Company.

Rudovsky, D. (2001). Law enforcement by stereotyping and serendipity: Racial profiling and stops and searches without cause. *University of Pennsylvania Journal of Constitutional Law*, 3(1), 296-366.

Sherman, L. W. (1990). Police crackdowns: Initial and residual deterrence. In M. Tonry & N. Morris (Eds.), *Crime and justice: A review of research*. Chicago, IL: University of Chicago Press.

Sherman, L. W. (1995). Hot spots of crime and criminal careers of places. In J. E. Eck & D. Weisburd (Eds.), *Crime and place* (pp. 35-65). Monsey, New York: Criminal Justice Press.

Sherman, L. W. (2001). Reducing gun violence: What works, what doesn't, what's promising. *Criminology and Criminal Justice*, 1(1), 11-25.

Sherman, L. W. (2003). Policing gun crimes: Comment by Lawrence W. Sherman. In J. Ludwig & P. J. Cook. (Eds.), *Evaluating gun policy: Effects on crime and violence* (pp. 240-243). Washington, DC: Brooking Institution Press.

Sherman, L. W., Gartin, P. R., & Buerger, M. E. (1989). Hot spots of predatory crime: Routine activities and the criminology of place. *Criminology*, 27(1), 27-55.

Sherman, L. W., & Rogan, D. P. (1995). Effects of gun seizures on gun violence: "Hot spots" patrol in Kansas City. *Justice Quarterly*, 12(4), 673-693.

Skogan, W. G., & Frydl, K. (2004). *Fairness and effectiveness in policing: The Evidence*. Washington, DC: National Academies Press.

Smith, D. A. (1986). The neighborhood context of police behavior. In A. J. Reiss & M. Tonry (Eds.). *Communities and crime* (pp. 313-341). Chicago: University of Chicago Press.

Sparks, R. F. (1981). Multiple victimization: Evidence, theory and future research. *Journal of Criminal Law and Criminology*, 72, 762-788.

Stafford, M. C., & Warr, M. (1993). A reconceptualization of general and specific deterrence. *Journal of Research in Crime and Delinquency,* 30(2), 123-135.

Taylor, R. B. (1997). Order and disorder of streetblocks and neighborhoods: Ecology, microecology and the systemic model of social organization. *Journal of Research in Crime and Delinquency*, 34, 113-155.

Taylor, R. B. (1998). Crime in small scale places: What we know, what we prevent, and what else we need to know. In *Crime and place: Plenary papers of the 1997 conference on criminal justice research and evaluation* (pp. 1-20), Washington, DC: National Institute of Justice.

Taylor, R. B. (2010). Hot spots do not exist, and four other fundamental concerns about hot-spots policing. In N. A. Frost, J. D. Freilich, & T. R. Clear (Eds.), *Contemporary issues in criminal justice policy* (pp. 271 – 278). Belmont, CA, Wadsworth.

Taylor, R. B., Gottfredson, S. D., & Bower, S. (1984). Understanding block crime and fear. *Journal of Research in Crime and Delinquency*, 21, 303-331.

Taylor, R. B., Harris, P. W., Jones, P. R., Weiland, D., Garcia, R. M., & McCord, E. S. (2009). Short-term changes in arrest rates influence later short-term changes in serious male delinquency prevalence: A time-dependent relationship. *Criminology*, 47(3), 657-697.

Terrill, W., & Reisig, M. D. (2003). Neighborhood context and police use of force. *Journal of Research in Crime and Delinquency*, 40, 291-321.

Timoney, J. F. (2001, May). Invited remarks. Cumberland County Community College Forum: New Directions in Policing. Vineland, NJ.

Tittle, C. R., & Rowe, A. R. (1974). Certainty of arrest and crime rates: A further test of the deterrence hypothesis. *Social Forces*, 52, 455-462.

Tobler, W. R. (1970). A computer movie simulating urban growth in the Detroit region. *Economic Geography*, 46, 234-240.

Tonry, M. (1995). *Malign neglect-race crime, and punishment in America*. New York: Oxford University Press.

Townsley, M., Homel, R., & Chaseling, J. (2000). Repeat burglary victimisation: Spatial and temporal patterns. *Australian and New Zealand Journal of Criminology*, 33, 37-63.

Townsley, M., Homel, R., & Chaseling, J. (2003). Infectious burglaries: A test of the near repeat hypothesis. *British Journal of Criminology*, 43, 615-633.

Tuch, S. A., & Weitzer, R. (1997). Racial differences in attitudes toward the police. *Public Opinion Quarterly*, 61, 642-663.

Turner, S. (1969). Delinquency and distance. In T. Sellen & M. E. Wolfgang (Eds.), *Delinquency: Selected studies*. New York: Wiley.

Tyler, T. (1984). Assessing the risk of victimization: The integration of personal victimization experiences and socially transmitted information. *Journal of Social Issues*, 40, 27-38.

United States Census Bureau. (2007). State and County Quick Facts. Retrieved March 01, 2009, from http://quickfacts.census.gov/qfd/states/42/42101.html.

United States Census Bureau. (2009). Population Division. Retrieved November 28, 2009 from http://www.census.gov/popest/overview.html.

Van Kammen, W. B., & Loeber, R. (1994). Are fluctuations in delinquent activities related to the onset and offset in juvenile drug use and drug dealing? *Journal of Drug Issues*, 24, 9-24.

Villaveces, A., Cummings, P., Espitia, V. E., Koepsell, T.D., Barbara, M., & Kellermann, A. L. (2000). Effect of a ban on carrying firearms on homicide rates in 2 Colombian cities. *The Journal of the American Medical Association*, 283(9), 1205-1209.

Weisburd, D., Bruinsma, G. J. N., & Bernasco, W. (2009). Units of analysis in geographic criminology: Historical development, critical issues, and open questions. In D. Weisburd, W. Bernasco, & G. J. N. Bruinsma (Eds.), *Putting crime in its place: Units of analysis in geographic criminology* (pp. 3-34). New York: Springer.

Weisburd, D., & Green, L. (1995). Policing drug hot spots: The Jersey City drug market analysis experiment. *Justice Quarterly*, 12(4), 711–735.

Weisburd, D., Morris, N., & Ready, J. (2008). Risk-focused policing at places: An experimental evaluation of the communities that care program in Redlands, California. *Justice Quarterly*, 25 (1), 163-200.

Weisel, D. L. (2005). Analyzing repeat victimization. Problem-oriented guides for police problem-solving tools series No. 4. Washington DC: U.S. Department of Justice/Community Oriented Policing Services.

Wilkinson, D. L., & and Fagan, J. (1996). The role of firearms in violence "scripts": The dynamics of gun events among adolescent males. *Law and Contemporary Problems*, 59(1), 55-89.

Wilson, J. Q., & Boland, B. (1978). The effect of police on crime. *Law & Society Review*, Spring, 367-390.

Wilson, J. Q., & Boland, B. (1981). The effects of the police on crime: A response to Jacob and Rich. *Law & Society Review*, 16(1), 163-169.

Wright, J. D., & Rossi, P. H. (1994). *Armed and considered dangerous: A survey of felons and their firearms* (Expanded Edition). New York: Alidine de Gruyter.

Wyant, B. R., & Taniguchi, T. A. (2009). Prosecuted for illegal firearm carrying in Philadelphia: 2005 - 2007. Paper presented at the annual meeting of the American Society of Criminology, Philadelphia, PA, November.

APPENDICES

A. Shooting and VUFA totals by police districts

Table 23: Shootings by police division and district: 2004 – 2007

	2004	2005	2006	2007	Total
Central division total	**218**	**228**	**276**	**218**	**940**
22nd	114	123	159	133	529
23rd	61	64	64	53	242
6th	31	30	30	22	113
9th	12	11	23	10	56
East division total	**255**	**264**	**287**	**277**	**1,083**
24th	57	69	83	82	291
25th	128	137	149	134	548
26th	70	58	55	61	244
Northeast division total	**90**	**96**	**158**	**104**	**448**
2nd	20	22	40	33	115
7th	6	9	5	1	21
8th	13	11	15	11	50
15th	51	54	98	59	262
Northwest division total	**293**	**284**	**290**	**275**	**1,142**
5th	1	2	2	2	7
39th	103	73	104	108	388
14th	90	109	89	90	378
35th	99	100	95	75	369
South division total	**131**	**171**	**202**	**150**	**654**
1st	23	44	63	28	158
3rd	12	13	17	13	55
4th	26	17	38	22	103
17th	70	97	84	87	338
Southwest division total	**397**	**382**	**443**	**381**	**1,603**
12th	115	106	154	126	501
18th	82	73	79	66	300
16th	73	75	67	59	274
19th	127	128	143	130	528
Philadelphia totals	**1,384**	**1,425**	**1,656**	**1,405**	**5,870**

INCT data provided by the Philadelphia Police Department

Table 24: VUFAs by police division and district: 2004 – 2007

	2004	2005	2006	2007	Total
Central division total	**262**	**247**	**230**	**192**	**931**
22nd	144	125	123	100	492
23rd	74	79	71	61	285
6th	24	28	21	24	97
9th	20	15	15	7	57
East division	**215**	**237**	**246**	**222**	**920**
24th	53	75	70	60	258
25th	118	128	137	113	496
26th	44	34	39	49	166
Northeast division total	**111**	**130**	**159**	**119**	**519**
2nd	31	38	29	22	120
7th	6	3	5	11	25
8th	2	8	10	10	30
15th	72	81	115	76	344
Northwest division total	**338**	**284**	**327**	**309**	**1,258**
5th	1	5	4	4	14
39th	109	91	83	92	375
14th	98	67	110	65	340
35th	130	121	130	148	529
South division total	**131**	**172**	**173**	**99**	**575**
1st	23	35	36	18	112
3rd	9	20	17	12	58
4th	17	12	23	12	64
17th	82	105	97	57	341
Southwest division total	**405**	**357**	**363**	**359**	**1,484**
12th	117	74	106	122	419
18th	112	83	108	87	390
16th	56	62	32	51	201
19th	120	138	117	99	474
Philadelphia totals	**1,462**	**1,427**	**1,498**	**1,300**	**5,687**

INCT data provided by the Philadelphia Police Department

B. Philadelphia pseudo *P*-values for question # 1

Table 25: Philadelphia statistical significance
Shooting and later VUFAs: 2004 – 2007

	Days between events							
Distance between events	0 to 2 days	3 to 4 days	5 to 6 days	7 to 8 days	9 to 10 days	11 to 12 days	13 to 14 days	15 + days
1-400 ft	**0.01**	0.49	0.08	0.42	0.45	0.07	0.43	1.00
401-800 ft	**0.01**	0.48	**0.01**	0.09	0.14	**0.02**	0.61	1.00
801-1200 ft	**0.04**	**0.02**	0.11	0.72	0.14	0.28	0.18	1.00
1201-1600 ft	**0.01**	0.53	0.13	0.18	1.00	**0.01**	0.46	1.00
1601-2000 ft	0.08	0.50	**0.01**	0.47	0.05	0.15	0.68	1.00
2001-2400 ft	0.14	**0.02**	0.20	**0.03**	0.39	0.35	0.07	1.00
2401-2800 ft	0.17	0.09	**0.04**	0.17	0.37	0.99	0.53	0.94
2801 ft +	**0.01**	**0.01**	**0.01**	**0.02**	**0.01**	**0.01**	**0.01**	1.00

Events = 11,511 (shooting n = 5,859; VUFA n = 5,652); Event pairs = 15,988,091
< .05 in bold

C. Central Police Division pseudo *P*-values for question # 1

Table 26: Central Police Division statistical significance
Shooting and later VUFAs: 2004 – 2007

	Days between events							
Distance between events	0 to 2 days	3 to 4 days	5 to 6 days	7 to 8 days	9 to 10 days	11 to 12 days	13 to 14 days	15 + days
1-400 ft	**0.01**	0.87	0.46	1.00	0.61	0.29	0.92	0.62
401-800 ft	0.38	0.97	0.56	0.91	0.65	**0.03**	0.61	0.63
801-1200 ft	**0.02**	0.62	0.51	0.45	0.21	0.55	0.40	0.98
1201-1600 ft	0.09	0.64	0.84	0.78	0.54	0.21	0.79	0.54
1601-2000 ft	0.23	0.48	0.11	0.62	0.37	0.30	0.18	0.94
2001-2400 ft	0.68	0.52	0.07	**0.02**	0.21	0.57	0.14	1.00
2401-2800 ft	0.15	0.05	0.52	0.35	0.49	0.95	0.96	0.53
2801 ft +	0.92	**0.01**	**0.01**	**0.01**	**0.02**	**0.01**	**0.03**	1.00

Events = 1,864 (shooting n = 939; VUFA n = 925); Event pairs = 393,698
< .05 in bold

D. East Police Division pseudo *P*-values for question # 1

Table 27: East Police Division statistical significance
Shooting and later VUFAs: 2004 – 2007

	Days between events							
Distance between events	0 to 2 days	3 to 4 days	5 to 6 days	7 to 8 days	9 to 10 days	11 to 12 days	13 to 14 days	15 + days
1-400 ft	**0.01**	0.70	0.15	0.77	0.70	0.32	0.82	1.00
401-800 ft	0.43	0.93	0.31	0.07	**0.01**	0.13	0.69	1.00
801-1200 ft	0.65	0.54	0.42	0.52	0.36	0.56	0.09	0.80
1201-1600 ft	0.14	0.43	**0.04**	0.10	0.32	**0.02**	0.50	1.00
1601-2000 ft	0.82	0.74	0.19	0.54	0.29	0.12	0.97	0.56
2001-2400 ft	0.36	**0.03**	0.52	0.15	0.86	0.18	0.09	0.97
2401-2800 ft	0.45	0.34	0.73	0.72	0.34	0.87	0.93	0.27
2801 ft +	0.21	0.05	0.53	1.00	**0.03**	0.07	0.08	0.98

Events = 1,995 (shooting n = 1,080; VUFA n = 915); Event pairs = 484,121
< .05 in bold

E. Northeast Police Division pseudo *P*-values for question # 1

Table 28: Northeast Police Division statistical significance
Shootings and later VUFAs: 2004 – 2007

	Days between events							
Distance between events	0 to 2 days	3 to 4 days	5 to 6 days	7 to 8 days	9 to 10 days	11 to 12 days	13 to 14 days	15 + days
1-400 ft	**0.01**	0.64	**0.03**	**0.03**	0.69	**0.03**	1.00	1.00
401-800 ft	0.53	0.90	0.49	0.34	0.12	0.27	0.93	0.78
801-1200 ft	0.66	0.16	0.58	0.97	0.95	0.73	0.59	0.31
1201-1600 ft	1.00	0.83	0.29	0.61	0.94	0.14	0.52	0.23
1601-2000 ft	0.56	0.76	0.58	0.60	0.83	0.37	0.11	0.64
2001-2400 ft	0.47	0.11	0.32	0.09	**0.04**	0.69	0.40	0.98
2401-2800 ft	0.94	0.71	0.71	0.51	0.09	0.98	0.57	0.30
2801 ft +	0.78	0.62	0.15	0.22	0.07	0.11	0.56	0.92

Events = 964 (shooting n = 447; VUFA n = 517); Event pairs = 110,341
< .05 in bold

F. Northwest Police Division pseudo *P*-values for question # 1

Table 29: Northwest Police Division statistical significance
Shooting and later VUFAs: 2004 – 2007

	Days between events							
Distance between events	0 to 2 days	3 to 4 days	5 to 6 days	7 to 8 days	9 to 10 days	11 to 12 days	13 to 14 days	15 + days
1-400 ft	**0.01**	0.21	0.46	0.70	0.68	0.16	**0.01**	1.00
401-800 ft	0.15	0.14	0.07	0.07	0.54	0.21	0.10	1.00
801-1200 ft	0.17	0.23	0.40	0.11	0.89	0.39	0.55	0.90
1201-1600 ft	0.05	0.63	0.52	0.63	0.96	0.11	0.21	0.81
1601-2000 ft	0.65	0.93	**0.03**	0.37	0.26	0.26	0.17	0.84
2001-2400 ft	0.51	0.22	0.75	0.78	0.63	0.64	0.92	0.24
2401-2800 ft	0.64	0.14	0.11	0.08	0.67	0.74	0.73	0.84
2801 ft +	0.98	0.46	0.20	0.22	0.68	0.13	0.86	0.50

Events = 2,388 (shooting n = 1,141; VUFA n = 1,247); Event pairs = 710,687
< .05 in bold

G. South Police Division pseudo *P*-values for question # 1

Table 30: South Police Division statistical significance
Shooting and later VUFAs: 2004 – 2007

	Days between events							
Distance between events	0 to 2 days	3 to 4 days	5 to 6 days	7 to 8 days	9 to 10 days	11 to 12 days	13 to 14 days	15 + days
1-400 ft	**0.01**	0.41	0.86	0.59	0.80	0.34	0.94	0.95
401-800 ft	**0.01**	**0.02**	0.17	0.46	0.45	0.37	0.22	1.00
801-1200 ft	0.97	**0.01**	0.30	0.86	0.13	0.13	0.32	0.99
1201-1600 ft	0.05	0.81	0.39	0.26	1.00	0.58	0.10	0.62
1601-2000 ft	0.37	0.31	0.09	1.00	0.60	0.62	0.63	0.48
2001-2400 ft	0.33	0.09	0.35	0.61	0.98	0.82	0.30	0.61
2401-2800 ft	0.16	0.39	0.13	0.12	0.73	0.96	0.12	0.94
2801 ft +	0.69	0.10	**0.01**	0.10	0.16	**0.01**	0.05	1.00

Events = 1,225 (shooting n = 652; VUFA n = 573); Event pairs = 172,655
< .05 in **bold**

H. Southwest Police Division pseudo *P*-values for question # 1

Table 31: Southwest Police Division statistical significance
Shooting and later VUFAs**:** 2004 – 2007

	Days between events							
Distance between events	0 to 2 days	3 to 4 days	5 to 6 days	7 to 8 days	9 to 10 days	11 to 12 days	13 to 14 days	15 + days
1-400 ft	**0.01**	0.47	0.35	0.29	0.21	0.48	0.71	1.00
401-800 ft	0.16	0.71	0.05	0.67	0.60	0.44	0.80	0.74
801-1200 ft	0.30	0.27	0.15	0.87	0.30	0.62	0.56	0.80
1201-1600 ft	0.06	0.34	0.16	0.10	0.98	0.38	0.53	0.96
1601-2000 ft	0.05	0.06	**0.02**	0.21	0.14	0.26	0.98	1.00
2001-2400 ft	0.22	0.61	0.51	0.37	0.67	0.32	0.10	0.89
2401-2800 ft	0.24	0.60	0.09	0.34	0.31	0.81	0.06	0.91
2801 ft +	1.00	**0.01**	**0.01**	0.15	**0.02**	**0.01**	**0.02**	1.00

Events = 3,075 (shooting n = 1,600; VUFA n = 1,475); Event pairs = 1,140,141
< .05 in bold

I. Philadelphia pseudo *P*-values for question # 2

Table 32: Philadelphia statistical significance
VUFA and later shootings: 2004 – 2007

	Days between events							
Distance between events	0 to 2 days	3 to 4 days	5 to 6 days	7 to 8 days	9 to 10 days	11 to 12 days	13 to 14 days	15 + days
1-400 ft	0.63	0.79	**0.01**	0.24	0.37	1.00	0.67	0.35
401-800 ft	0.95	**0.01**	**0.02**	0.07	0.92	0.08	0.45	0.95
801-1200 ft	0.06	0.36	0.17	0.08	**0.01**	0.30	0.05	1.00
1201-1600 ft	0.60	0.26	0.41	**0.03**	0.06	0.08	0.38	1.00
1601-2000 ft	**0.02**	0.33	0.47	0.05	0.04	0.09	**0.04**	1.00
2001-2400 ft	0.15	**0.02**	0.12	0.06	0.95	0.14	**0.02**	1.00
2401-2800 ft	0.07	0.44	**0.02**	0.09	0.62	0.51	0.16	1.00
2801 ft +	**0.01**	**0.01**	**0.01**	**0.02**	**0.01**	**0.01**	**0.01**	1.00

Events = 11,511 (VUFA n = 5,652; shooting n = 5,859); Event pairs = 17,347,253
< .05 in bold

J. Central Police Division pseudo *P*-values for question # 2

Table 33: Central Police Division statistical significance
VUFA and later shootings: 2004 – 2007

	Days between events							
Distance between events	0 to 2 days	3 to 4 days	5 to 6 days	7 to 8 days	9 to 10 days	11 to 12 days	13 to 14 days	15 + days
1-400 ft	0.83	0.75	**0.04**	0.42	0.23	0.66	0.32	0.90
401-800 ft	0.96	0.13	0.46	0.23	0.44	0.18	0.15	0.93
801-1200 ft	0.19	0.48	0.37	0.38	**0.04**	0.05	0.46	1.00
1201-1600 ft	**0.01**	0.14	0.30	0.35	0.26	0.47	0.71	1.00
1601-2000 ft	0.32	0.73	0.72	**0.03**	**0.03**	0.05	0.14	1.00
2001-2400 ft	0.05	0.07	0.78	0.14	0.81	0.39	0.11	0.95
2401-2800 ft	0.10	0.52	**0.03**	0.08	0.25	0.12	0.20	1.00
2801 ft +	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.02**	1.00

Events = 1,870 (VUFA n = 925; shooting n = 939); Event pairs = 475,816
< .05 in bold

K. East Police Division pseudo *P*-values for question # 2

Table 34: East Police Division statistical significance
VUFA and later shootings: 2004 – 2007

	Days between events							
Distance between events	0 to 2 days	3 to 4 days	5 to 6 days	7 to 8 days	9 to 10 days	11 to 12 days	13 to 14 days	15 + days
1-400 ft	0.41	0.82	0.09	0.28	0.94	0.81	0.99	0.28
401-800 ft	0.71	0.16	**0.04**	0.52	0.68	0.08	0.82	0.95
801-1200 ft	**0.04**	0.82	0.14	0.80	**0.03**	0.62	0.07	0.98
1201-1600 ft	0.87	0.87	0.29	0.25	0.09	0.23	0.18	0.85
1601-2000 ft	0.17	0.36	0.56	0.33	0.63	0.60	**0.02**	0.95
2001-2400 ft	0.13	0.48	0.58	0.26	0.55	0.98	0.36	0.60
2401-2800 ft	0.20	0.20	0.69	0.63	0.85	0.97	0.65	0.31
2801 ft +	**0.01**	0.47	0.33	**0.04**	**0.01**	0.28	**0.01**	1.00

Events = 1,995 (VUFA n = 915; shootings n = 1,080); Event pairs = 508,990
< .05 in bold

L. Northeast Police Division pseudo *P*-values for question # 2

Table 35: Northeast Police Division statistical significance
VUFA and later shootings: 2004 - 2007

	Days between events							
Distance between events	0 to 2 days	3 to 4 days	5 to 6 days	7 to 8 days	9 to 10 days	11 to 12 days	13 to 14 days	15 + days
1-400 ft	0.61	0.27	0.71	0.82	0.85	1.00	0.29	0.12
401-800 ft	0.61	0.46	**0.04**	0.73	0.42	0.43	0.96	0.75
801-1200 ft	0.33	0.52	0.70	0.47	0.52	0.61	0.46	0.85
1201-1600 ft	0.72	0.44	0.75	0.92	0.22	0.64	0.88	0.29
1601-2000 ft	0.07	0.86	0.97	0.83	**0.04**	0.93	0.49	0.34
2001-2400 ft	0.97	0.36	0.36	0.15	0.84	0.54	0.68	0.48
2401-2800 ft	0.44	0.87	0.89	0.14	0.29	0.62	0.27	0.74
2801 ft +	0.10	0.92	0.16	0.26	**0.01**	0.39	0.14	0.99

Events = 964 (VUFA n = 517; shooting n = 447); Event pairs = 121,275
< .05 in bold

M. Northwest Police Division pseudo *P*-values for question # 2

Table 36: Northwest Police Division statistical significance
VUFA and later shootings: 2004 – 2007

	Days between events							
Distance between events	0 to 2 days	3 to 4 days	5 to 6 days	7 to 8 days	9 to 10 days	11 to 12 days	13 to 14 days	15 + days
1-400 ft	0.95	0.79	0.35	0.47	**0.04**	0.98	0.80	0.44
401-800 ft	0.87	0.28	0.52	0.56	0.76	0.92	0.52	0.34
801-1200 ft	0.60	0.58	0.52	0.10	0.32	0.80	0.85	0.63
1201-1600 ft	0.94	0.62	**0.03**	0.13	0.91	0.45	0.93	0.34
1601-2000 ft	0.34	0.44	0.09	0.34	0.47	0.36	0.62	0.87
2001-2400 ft	0.37	0.37	0.37	0.12	0.98	0.12	0.10	0.94
2401-2800 ft	0.51	0.88	0.10	0.38	0.71	0.20	0.26	0.80
2801 ft +	0.07	0.53	0.27	0.09	0.88	0.08	0.35	0.90

Events = 2,388 (VUFA n = 1,247; shooting n = 1,241); Event pairs = 717,955
< .05 in bold

N. South Police Division pseudo *P*-values for question # 2

Table 37: South Police Division statistical significance
VUFA and later shootings: 2004 – 2007

	Days between events							
Distance between events	0 to 2 days	3 to 4 days	5 to 6 days	7 to 8 days	9 to 10 days	11 to 12 days	13 to 14 days	15 + days
1-400 ft	0.63	0.82	0.46	0.73	0.30	0.99	0.92	0.16
401-800 ft	0.54	0.18	0.62	0.56	0.40	0.21	0.32	0.96
801-1200 ft	0.09	0.54	0.48	0.39	0.13	0.62	0.24	0.99
1201-1600 ft	0.45	**0.01**	0.88	0.44	0.34	0.29	0.07	0.96
1601-2000 ft	0.53	0.19	0.20	0.11	0.08	0.42	0.78	0.93
2001-2400 ft	0.69	0.28	0.09	0.18	0.48	0.12	0.26	0.99
2401-2800 ft	0.54	0.40	0.45	0.73	0.82	0.49	0.20	0.65
2801 ft +	**0.01**	0.09	**0.01**	**0.02**	0.95	**0.01**	**0.01**	1.00

Events = 1,225 (VUFA n = 573; shooting n = 652); Event pairs = 199,471
< .05 in bold

O. Southwest Police Division pseudo *P*-values for question # 2

Table 38: Southwest Police Division statistical significance
VUFA and later shootings: 2004 – 2007

	Days between events							
Distance between events	0 to 2 days	3 to 4 days	5 to 6 days	7 to 8 days	9 to 10 days	11 to 12 days	13 to 14 days	15 + days
1-400 ft	0.49	0.75	0.32	0.25	0.76	0.80	0.21	0.69
401-800 ft	0.80	0.41	0.29	**0.04**	1.00	0.53	0.16	0.61
801-1200 ft	0.39	0.05	0.45	0.15	0.14	0.78	0.09	0.98
1201-1600 ft	0.65	0.74	0.95	0.18	0.08	0.32	0.28	0.71
1601-2000 ft	0.01	0.29	0.49	0.29	0.65	0.44	0.07	0.98
2001-2400 ft	0.26	0.12	0.14	0.44	0.66	0.20	0.61	0.97
2401-2800 ft	0.06	0.50	0.08	0.12	0.24	0.42	0.78	0.98
2801 ft +	**0.01**	**0.01**	**0.01**	**0.01**	0.08	0.59	**0.01**	1.00

Events = 3,075 (VUFA n = 1,475; shooting n = 1,600); Event pairs = 1,221,078
< .05 in bold